Oregon Agricultural College
Experiment Station

Director's Report
1918-1920

JANUARY, 1921

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W. M. ATWOOD, Ph. D. ..... Associate Professor of Plant Physiology
H. P. BARSS, A. B., S. M. ..... Chief in Botany and Plant Pathology
A. G. BOUQUET, B. S. ..... Professor of Vegetable Gardening
P. M. BRANDT, A. M. ..... Chief in Dairy Husbandry
G. G. BROWN, B. S. ..... Horticulturist, Hood River Br. Exp. Station, Hood River
W. S. BROWN, M. S. ..... Chief in Horticulture
D. E. BULLIS, B. S. ..... Research Assistant in Agricultural Chemistry
V. D. CHAPPELL, M. S. ..... Assistant Professor of Dairy Manufacturing
W. J. CHAMBERLIN, B. S. ..... Forest Entomologist
LEROY CHILDS, A. B. ..... Supt. Hood River Branch Experiment Station, Hood River
G. V. COPSON, M. S. ..... Chief in Bacteriology
WARD CRETCHER, B. S. ..... Assistant in Soils
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JAMES DRYDEN ..... Chief in Poultry Husbandry
A. E. ENGBRETSON, B. S. ..... Supt. John Jacob Astor Br. Exp. Station, Astoria
B. B. FULTON, M. S. ..... Assistant Professor of Entomology
W. V. HALVERSEN, M. S. ..... Assistant Professor of Bacteriology
E. M. HARVEY, Ph. D. ..... Professor of Horticultural Research
G. R. HYSLOP, B. S. ..... Chief in Farm Crops
W. W. JOHNSTON, B. S. ..... Assistant in Soils
J. S. JONES, M. S. ..... Chief in Agricultural Chemistry
R. C. JONES, B. S., in Agr. ..... Associate Professor of Dairy Husbandry
F. L. KNOWLTON, B. S. ..... Research Assistant in Poultry Husbandry
F. H. LATHROP, M. S. ..... Associate Professor of Entomology
W. E. LAWRENCE, B. S. ..... Associate Professor of Plant Ecology
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M. B. McKAY, M. S. ..... Associate Plant Pathologist
J. R. NEVIUS, B. S. ..... Assistant in Farm Crops
A. W. OLIVER, B. S. ..... Assistant in Animal Husbandry
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W. L. POWERS, M. S. ..... Chief in Soils
J. C. REEDER, B. S. ..... Research Assistant in Agricultural Chemistry
E. C. REIMER, M. S. ..... Supt. Southern Oregon Br. Exp. Station, Talent
D. W. RITCHIE, B. S. ..... Assistant in Soils
R. H. ROBINSON, M. S. ..... Associate Professor of Agricultural Chemistry Research
C. C. RUTH, M. S. ..... Assistant Professor of Farm Crops
C. V. RUZEK, B. S. ..... Associate Professor of Soils
H. A. SCHOTH, M. S. ..... U. S. Dept. of Agr., Scientific Assistant in Forage Crops
C. E. SCHUSTER, B. S. ..... Assistant Professor of Pomology; Station Pomologist
H. D. SCUDDER, B. S. ..... Chief in Farm Management
OBIL SHATTUCK, M. S. ..... Supt. Harney County Branch Experiment Station, Burns
J. N. SHAW, D. V. M. ..... Assistant in Veterinary Medicine
B. T. SIMMS, D. V. M. ..... Chief in Veterinary Medicine
W. A. SMART, B. S. ..... Research Ass't in Horticulture, Entomology, and Plant Pathology
D. E. STEPHENS, M. S. ..... Supt. Sherman County Dry-Farm Br. Exp. Station, Moro
G. F. SYKES, A. M. ..... Chief in Zoology and Physiology
E. F. TORGERSON, B. S. ..... Assistant Professor of Soils
E. H. WIEGAND, B. S. ..... Assistant Professor of Horticultural Products
H. M. WIGHT, M. S. ..... Assistant Professor of Zoology
ROBERT WITHYCOMBE, B. S. ..... Supt. Eastern Oregon Br. Exp. Station, Union
HORACE M. WOOLMAN ..... Field Ass't, Office of Cereal Investigations, U. S. Dept. Agri.
S. M. ZELLER, Ph. D. ..... Associate Plant Pathologist

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TO THE PRESIDENT OF THE COLLEGE

Sir:

We have the honor to submit herewith the report of the Agricultural Experiment Station of the Oregon State Agricultural College for the biennium ended June 30, 1920. It includes a brief account of the work in progress and results, and directs attention to the importance of agricultural investigations and to the needs of the Station if it is efficiently to meet its responsibilities in connection with the agriculture of the State.

A. B. CORDLEY,
Director to June 1, 1920.

JAMES T. JARDINE,
Director.

Report of Director

OREGON AGRICULTURAL EXPERIMENT STATION

For the Biennium July 1, 1918, to June 30, 1920

INTRODUCTION

During the four years prior to July 1, 1918, the work of the Agricultural Experiment Station has been seriously restricted through lack of funds. The situation remained unchanged until increases in appropriations were granted by the legislature at its session in 1919. Unfortunately these increases in appropriations were in no small measure offset by difficulty in securing and retaining well-trained men, and by constantly increasing cost for all items involved in conducting the Station work. During the biennium there were twenty-two resignations from the technical staff, and thirty-three new staff members were appointed. The cost of travel greatly increased; the cost of issuing publications increased approximately fifty percent; equipment continued to advance in price; labor costs increased greatly; and salaries were finally substantially increased in order to secure men qualified for investigational work.

These conditions and the increased demand for the aid of Station staff members on other than investigational work, made difficult the planning and continuation of investigations, and naturally retarded progress. In spite of the difficulties, however, many investigations have shown favorable progress and have resulted in valuable service to agriculture of the State. Brief statements of the investigations under way and results secured are given in later pages of this report. More complete reports of the work under the appropriations for Soil Investigations and for Crop Pest and Horticultural Investigations are published separately.

IMPORTANCE OF AGRICULTURAL INVESTIGATIONS

The agricultural experiment stations were established to investigate agricultural problems pressing for solution. There is sometimes a feeling that most of the problems should now be solved, since stations have been in existence many years. No idea could be more erroneous or more harmful to agricultural development.

Agriculture is a rapidly developing industry and is becoming more and more complex with changing economic and agricultural conditions. New problems have arisen more rapidly than funds have increased for the support and expansion of the agricultural experiment stations, and never before was there more pressing need for new, reliable information that can come only from study and investigation. While it may be true that agricultural practices developed and recommended by experiment stations are in many instances in advance of the average farming practice, these differences are disappearing as a consequence of the support and rapid development of the agricultural extension work. Further, the farmer knows that as a rule the experimental work should be years in

advance of farm practice in order that new principles, new methods, new crops, and new varieties may be thoroughly tested before they are urged for adoption by farmers.

Oregon, certainly, is no exception in its need for new information and new investigations. Few states, if any, vary more in topography, soils, climate and all other factors which determine agricultural production; and few, if any, have greater diversity of problems. With only a small portion of the State under cultivation and a great area waiting to be placed under cultivation, agricultural development is in its infancy. Except for a few specialized phases, agricultural practices of the State, too, are in their infancy. The opportunities for development are great throughout the State, but the problems of working out permanently profitable agricultural practice are many and complex, due to the greatly varying conditions within the State and variation from conditions of other states.

Agricultural investigations, therefore, must be a dominant factor in preparing the way for agricultural development, agricultural practice, and agricultural education in Oregon, for Oregon conditions. The Agricultural Experiment Station can meet this responsibility only in proportion to the funds made available. It is conservative to say that demands and real need for new information will exceed any expansion of the investigations that can be hoped for even under a most liberal policy of appropriations. At present the Station in many, if not most lines of investigation, is by no means as far in advance of agricultural practice as it should be for the best interest of the farmers and of the State.

ADDITIONAL INVESTIGATIONS IMPORTANT

Attention is directed especially to the following problems, some of which are of immediate importance to farmers of the State, and others urgent because the time required for their investigation and solution will make it impossible to secure the information as soon as it is needed. These and many others of less immediate practical importance are unanswered and can be investigated only as additional funds commensurate with the nature and number of the problems are provided.

CROP IMPROVEMENT

Our leading farm crops today are not well suited to some sections of the State. A new wheat is needed for Southeastern Oregon to meet climatic conditions there. New vetches, which will retain seed, are needed. Present vetches lose 5 to 50 percent of seed by shattering. This discourages the culture of this extremely important crop. Red clover, an important crop, is being attacked by disease. A disease-resistant red clover is needed. For Eastern Oregon a beardless rye is important, because rye is the hay crop for a large territory, and varieties most used are objectionable on account of beards. Smut-resistant varieties of wheat are important. Preliminary investigations on this problem have given promising results, but the final solution is a matter of time and most careful selection and breeding.

Problems similar to these have been solved elsewhere by investigations in crop improvement. Such investigations are fundamental to the finding of better varieties. Results from such work usually are not im-

mediate. If the first seed of a crop selected would overcome a difficulty under study it would take at least six years or more to have the new varieties thoroughly tested and ready to distribute even in small amounts to farmers. If we are to look forward, therefore, to advancement in our agriculture in the State from crop improvement, investigations should be undertaken at once and vigorously. A specialist should be provided to lead this work at the home Station and cooperate with the branch stations to meet the needs of the entire State.

TILLAGE INVESTIGATIONS

The importance of proper methods of tillage in successful farm practice can hardly be over-emphasized. The time, method, and amount of tillage greatly influence the cost of production and amount of crop produced. At the Sherman County branch station, for example, the investigations on methods of tillage for wheat production under the summer-fallow system have shown that early plowing of summer fallow is a prime factor in successful wheat production in the Columbia Basin. This information has already been responsible for an annual increase of thousands of bushels of wheat, and will result in further increase in production, as more farmers arrange their operations so that they can follow the practice recommended. Aside from these data for the one phase of farming and the one section of the State, the Experiment Station has little information and only limited investigations under way. Improved methods of tillage and better varieties may mean success or failure of cereal production in Southeastern Oregon, and more information on tillage for the leading farm crops of Western Oregon is much needed. In fact, methods of tillage will continue to be fundamental and a most important and permanent factor in profitable farming. Reliable results of investigations in the subject can be secured only through years of experimentation. The need is already here and the investigations under way are entirely inadequate.

CROP ROTATIONS

Cropping systems which will be most profitable without unwarranted soil depletion over a period of years are of first importance to successful agriculture. The need for such a system is already apparent in the Willamette Valley by reduced yields, high production costs, and difficulties in securing stands of crops like clover. Similar difficulties will no doubt come with time in other sections of the State. The idea should be to work for the most profitable system of crop rotations, keeping in mind useful crops, maintenance of soil fertility, economy and distribution of labor, gross production and net profit. This requires comparative experimental study of many crop rotation systems over a period of years. Such studies along with experiments in permanent soil fertility, experiments in tillage, and in crop improvement are imperative to advancement in the big, all-important problem of keeping farming lands of the State permanently productive under systems of agriculture which will be profitable with changing conditions as regards markets for different crops, availability and price of fertilizers, labor, machinery, and other items. The Station investigations in crop rotations, like the others mentioned, are entirely inadequate to meet the problems and needs of the State now, to say nothing of those of the future.

WEED CONTROL

In Oregon there are already six troublesome perennial weeds, difficult to control or eradicate, which are reducing crop yields and land values from 15 to 35 percent. At best the weed problems of the State will be difficult to handle, and the difficulty will increase with delay in methods of control and eradication. Investigations on this problem should be centered in one well-trained man at the home Station, who will conduct the work in the State in cooperation with branch stations and individuals.

PASTURES

The home Station has received hundreds of letters asking for information on pasture mixtures. The pasture problem is important for all territory west of the Cascades. The Station has undertaken no investigations of importance on this problem. There are four rather distinct regions involved and reliable answers will be possible only through experimentation; the answer is of much importance to livestock production and to dairying.

GRAIN STANDARDIZATION

The most important cereal crop of Oregon is wheat—perhaps 21,000,000 bushels worth $50,000,000 in 1920. We have practically no information on milling values as affected by variety, texture, mixture, presence of smut, wetting during and after harvest, and frost. These data are needed to improve our grain standards and give more accurate information on the value of wheat. More information is needed on changes in volume and value of cereals during storage. This information would be of great advantage to farmers in marketing their wheat crop.

SOIL INVESTIGATIONS

Soil reclamation, improvement and preservation are vital to development and permanency of profitable agriculture in Oregon. The problems are many and difficult. Investigations are under way and have shown good progress from the small appropriation granted for soil investigations by the legislature at its 1919 session.

This appropriation, however, covers soil fertility investigations, soil surveys, irrigation investigations, drainage investigations and surveys of both prospective irrigation and drainage projects to determine their feasibility agriculturally. While a great deal of useful information has been secured and helpful service rendered, the investigations are entirely inadequate to meet the needs or the calls for immediate information on these important subjects.

Soil fertility investigations should be expanded so as to develop permanently profitable systems of soil management before the lands are worn to the point of unprofitable production. This will necessitate more field trials with fertilizers, supplemented by laboratory and greenhouse studies, and more thorough studies of soil management and fertility with different crops and cropping systems.

The soil surveys serve as an invoice to the agricultural resources of the State and form the basis for effective use of information on crops

and soil management already available and for further investigations. The United States Bureau of Soils cooperates in this work and bears over one-half the expense.

Economical use of irrigation water is necessary, if the highest productive land values are to be realized and retained under irrigation. The amount of water rather than the land usually is the limiting factor in Oregon and any saving from more economical use of water is vitally important. The amount of water and the methods of using it to give the best returns, vary greatly under Oregon conditions and for different crops. More information is needed at once and the investigations have just reached the outskirts of the problems.

Drainage should eventually reclaim or double the productiveness of about 3,000,000 acres of Oregon lands. The most economical methods of draining and the management of wet, tide, overflow, and alkali lands, require investigation to secure best returns from $75,000,000 or more that will be required for drainage reclamation in the State.

More information on these subjects from actual investigations and field tests for different conditions in different parts of the State are much needed both for agricultural development and for permanently profitable agriculture. To delay such investigations cannot but result in loss to the farmers and to the State. The problems are so distributed throughout the State and conditions vary so much that the present appropriation of $7500 annually, under present high cost of conducting work, will provide at best for only limited investigations and tests useful for immediate guidance in agricultural practices, but not sufficient as a basis for more permanent agricultural practice.

DAIRY INVESTIGATIONS

At the legislative session in 1919, an appropriation of $5000 was made for investigation of problems confronting the dairy industry of the State. This fund was used in an investigation of infectious abortion because of the heavy losses from this disease, sterility, and kindred diseases, estimated as high as $5,000,000 annually in Oregon alone. These studies should be continued.

Problems of production in dairying, having largely to do with the economical use of feed by the cow, are of immediate importance throughout the State and there is little well-proved information concerning Oregon conditions and the feeds most readily available. Studies should be undertaken to develop milk substitutes from home-grown materials for raising calves. Investigations are much needed to determine comparative feeding value of silage from different crops which can be grown in dairying sections of the State. The comparative feeding value of high-protein concentrates should be studied. The maximum use of roughage in the production of milk, and the wintering of dairy animals are both problems for which information is daily much needed by the developing dairy industry.

CROP PEST AND HORTICULTURAL INVESTIGATIONS

Despite the fact that the Oregon Agricultural Experiment Station has high standing for the amount and character of its investigations in crop pest and horticultural subjects, there are many problems which should be studied at the earliest opportunity. Their importance and character are illustrated by the following few examples.

Pear-thrips. The pear-thrips appeared first in Oregon in destructive numbers in 1918, affecting an area of about 100 acres of fine bearing prunes, resulting in total destruction of the prune crop and serious injury to pear and cherry crops. Adjacent areas and other fruit districts of the State are concerned about this pest. From a careful investigation of conditions in California, it would appear that the thrip is much more serious on pears than on prunes, but that even on prunes it may be expected that every year the crop will be materially reduced in quality and that total loss of crops will occur at least one season in three. A vigorous campaign against this pest should be carried forward before the pest is generally distributed and generally destructive. Our present knowledge would indicate that the presence of this pest over the State would, at best, materially increase the cost of fruit production due to the cost of control measures.

Grasshoppers. In the greater plain area of Eastern Oregon the grasshopper problem is a serious one. The annual loss due to this pest is probably $1,000,000. Preliminary studies indicate that the serious losses are avoidable. Until the problem is more definitely investigated, in order to work out and demonstrate satisfactory methods of grasshopper control, however, emergency calls for assistance will continue to reach the Experiment Station at times when serious losses cannot be entirely prevented and the cost of combating the outbreaks will be very heavy.

Alfalfa Weevil. Incomplete figures indicate that there are approximately 150,000 acres of alfalfa in Oregon. The alfalfa weevil is present in Malheur county, and where this pest is present, it is reducing the yield to a point where the crop is profitless. There is no logical reason why the alfalfa weevil cannot spread to every part of the State where alfalfa is grown on a commercial basis. Portions of the State now affected by the weevil are quarantined by all adjacent states. In addition to alfalfa hay, almost all other money crops are likewise under quarantine and cannot be moved to these states from the weevil-infested areas.

Most facts concerning the life-history of alfalfa weevil are available. Some problems in control need solution, particularly as to the cost and method of applying sprays for control. These problems should be given attention at once, rather than delayed until the weevil spreads.

Insect Pests of Yellow Pine. There are in Oregon over 10,000,000 acres of yellow pine forests in which insect pests perhaps equal or exceed in destructiveness, all other agencies. Owners in Southern Oregon estimate a loss of over $200,000 annually due to yellow pine bark-beetles. The general injury by these pests has become so serious that timber interests in Oregon have requested State aid in the solution of the problem, and in cooperation with these interests the Experiment Station undertook preliminary investigations in control measures for the bark-beetle early in 1920. If continued, however, these investigations should be provided for by additional appropriations.

Fruit Diseases. The acreage of small fruits is very greatly increasing in Oregon. There is no one on the Experiment Station staff to make a study of diseases attacking these crops or to experiment with practical measures of control under Oregon conditions. Similarly there is no one to study insect control for these crops. Oregon is rapidly developing

into a walnut-producing state. It is estimated that 25 percent of this crop is lost annually from walnut blight. This disease has been prevalent in California for many years but no successful control methods have been worked out. Preliminary investigations on walnut blight were undertaken with promise of success by the Oregon Station several years ago but were discontinued through lack of funds. Other disease investigations now under way might well be undertaken more aggressively and additional new ones are worthy of serious consideration.

COST OF PRODUCTION AND FARM MANAGEMENT STUDIES

It is not improbable that the Station may be called upon at any time to conduct studies and report cost of production of agricultural products essential to public welfare, and there are many opportunities for improvement from thorough studies of farm management.

To be reliable, such studies should be made by men thoroughly trained for such work and at the same time thoroughly acquainted with all operations involved in production of the crop in question within the territory under study. To be most useful, such studies should be well under way before the data are most needed, otherwise the main need of the data may pass before the studies can be completed. In such case the immediate value is lost. It is only fair to point out that the Station at present has no staff members trained for such work and no funds to provide for such members and is therefore not prepared to meet an emergency call by immediate investigations. At least there should be one man on the staff thoroughly qualified to lead such studies.

NEEDS OF THE STATION

In the foregoing pages the importance of agricultural investigations to agricultural development, agricultural practice, and the teaching of agriculture in Oregon, and a few of the more immediate problems which are not under investigation, are presented briefly.

In addition, attention is directed to the fact that the purchasing value of the dollar for investigational work of the Station is little more than sixty percent as great at the beginning of the new biennium as it was two years ago, due to necessary increases in salaries and marked increases in all other costs.

Owing to reduced appropriations for agricultural investigations by the Federal Department of Agriculture, cooperation by the Federal Government has been withdrawn from the Umatilla branch station, from the Harney County branch station, and in part from the Sherman County branch station.

If the facts are faced, this can mean only one of two things. Either the present program of investigations and the Station staff must be reduced thirty to forty percent or additional funds must be provided. Obviously, therefore, if the present investigations are to be continued and any or all of the additional investigations mentioned are to be undertaken, the appropriations for the experimental work must be increased accordingly. There can be no other conclusion.

Additional farm land is badly needed if well-planned experiments, especially in farm crops and soils work, are to be undertaken. Additional greenhouse space is imperative to most effective investigations in nearly

all departments. Additional laboratory space would add to efficiency of the experimental work. A seed house suitable for use by all departments would result in a big annual saving of seed stocks, and of valuable experimental material now inadequately protected against weather, rodents, and livestock. All departments using gas in experimental work have complained of reduced efficiency from poor and inadequate gas supply. Purchase of equipment has been limited to that imperative to continuation of investigations under way. Additional equipment is needed. Publications have been somewhat limited in number and editions have been reduced to 3000 or at most 5000 copies. A few of the publications issued within the biennium are already exhausted and there is still demand for them. A more liberal publication policy is advisable for best use of the Station results.

PERSONNEL

The following changes in the personnel of the Station staff took place during the biennium:

RESIGNATIONS

A. F. Barss, M.S., Research Assistant in Horticulture.

Theodore Day Beckwith, M.S., Chief in Bacteriology.

Asa C. Chandler, Ph.D., Assistant Professor of Zoology.

J. E. Cooter, B.S., Instructor in Soils.

Solomon Fine, M.S., M.A., Instructor in Dairy Husbandry.

Erza James Fjeldsted, B.S., Assistant Professor of Animal Husbandry.

V. E. Gardner, M.S., Pomologist.

Walter Kocken, B.S.A., Orchard Foreman.

E. J. Kraus, Ph.D., Professor of Horticultural Research.

Claude Isaac Lewis, M.S.A., Vice-director Experiment Station and Chief in Horticulture.

L. S. Lingle, A. B., Assistant in Horticulture.

Paul Stanley Lucas, B.S.A., Assistant Professor of Dairy Husbandry.

John Holmes Martin, B.S., Supt. Harney Co. Branch Experiment Station.

David Masterton, Manager of Greenhouse.

Andrew Cameron McCormick, B.S., Assistant Southern Oregon Branch Experiment Station.

O. M. Nelson, B.S., Assistant in Animal Husbandry, transferred to Extension Service.

Jessie P. Rose, Research Assistant in Botany.

H. V. Tartar, B.S., Chief in Agricultural Chemistry.

Harold Roy Taylor, B.S., Supt. John Jacob Astor Branch Experiment Station.

B. F. Sheehan, M.S., Assistant Professor of Farm Crops.

Franklin Scott Wilkins, M.S., Professor of Farm Crops.

Leon Walton Wing, B.S., M.A., Instructor in Dairy Husbandry.

APPOINTMENTS

W. M. Atwood, Ph.D., Associate Professor of Botany; Plant Pathologist.

W. S. Averill, B.S., Assistant in Farm Crops.

A. B. Black, B.S., Assistant Entomologist.

W. S. Brown, M. S., Chief in Horticulture.

J. M. Clifford, Secretary to Director.

G. V. Copson, M.S., Chief in Bacteriology.

Ward Cretcher, B.S., Assistant in Soils.

A. E. Engbretson, B.S., Supt. John Jacob Astor Branch Station.

Dennis Cooter, Orchard Foreman.

S. Fine, M.S., M.A., Instructor in Dairy Husbandry.

B. B. Fulton, M.S., Assistant Professor of Entomology.

Oliver Hamm, Manager of Greenhouse.

W. V. Halversen, M.S., Assistant Professor of Bacteriology.

E. M. Harvey, Ph.D., Assistant in Horticultural Research.

James T. Jardine, B.S., Director of Experiment Station.

W. W. Johnston, B.S., Irrigation Field Agent.

J. S. Jones, M. S., Chief in Agricultural Chemistry.

F. L. Knowlton, B.S., Research Assistant in Poultry Husbandry.

F. H. Lathrop, M.S., Assistant Entomologist.

M. B. McKay, M.S., Associate Professor of Botany and Plant Pathology.

F. W. Miller, D.V.M., Assistant in Veterinary Medicine.

A. W. Oliver, B.S., Assistant in Animal Husbandry.

Palmer Patton, B.S., Research Assistant in Farm Management. Resigned.

J. C. Reeder, B.S., Research Assistant in Agricultural Chemistry.

B. W. Rodenwold, B.S., Assistant Professor of Animal Husbandry.

C. C. Ruth, M.S., Assistant Professor of Farm Crops.

Obil Shattuck, M.S., Supt. Harney County Branch Experiment Station.

W. A. Smart, B.S., Crop Pest Assistant.

E. F. Torgerson, B.S., Assistant Professor of Soils.

E. H. Wiegand, B.S., Research Assistant in Horticultural Products.

J. S. Wieman, B.S., Assistant in Horticultural Products.

F. S. Wilkins, M.S., Assistant Professor of Farm Crops.

L. W. Wing, B.S., M.A., Instructor in Dairy Husbandry.

S. M. Zeller, Ph.D., Associate Plant Pathologist.

PUBLICATIONS

Sixteen Station bulletins and two Station circulars were issued during the biennium. In addition the Station staff prepared a number of papers for publication as bulletins of the Extension Service and a considerable number of technical papers for publication in scientific journals.

BULLETINS

Number	*Title*	*Edition*	*Pages*
157	The Improvement of Marsh Lands in Western Oregon	3000	37
158	Pollination of Tomatoes	3000	29
159	Fertilizer Tests for Strawberries	3000	15
160	The Small Irrigation Pumping Plant	3000	16
161	Duty of Water in Irrigation	3000	20
162	Pear Harvesting and Storage Investigations in Rogue River Valley	3000	39
163	Sulfur as a Fertilizer for Alfalfa in Southern Oregon	5000	40
164	The Soils of Jackson County	3500	62
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172	The Western Pine Bark-beetle	3000	30
.....	Soil Survey of Yamhill County, Oregon (In Cooperation with U. S. Department of Agriculture, Bureau of Soils).	4000	66

CIRCULARS

Number		*Edition*	*Pages*
21	Commercial Fertilizers	2000	16
22	Fruit Grower's Handbook of Apple and Pear Insects	3000	72

SUMMARIES OF PUBLICATIONS

Station Bulletins

157. The Improvement of Marsh Lands in Western Oregon, W. L. Powers. This bulletin discusses the improvement of marsh lands through drainage and replacement of wild growth by farm crops. Methods of tiling used on overflow and tide lands at the Astoria branch station are described. Drainage district procedure under the Oregon Drainage Law is outlined and the design and construction of dikes, tide boxes, outlet ditches, and pumping plants, as well as the probable cost of installing drainage and the increased crop production from drainage, are briefly discussed.

158. **Pollination of Tomatoes**, A. G. Bouquet. This bulletin reports continued observations regarding the fruitfulness of tomato plants under glass and discusses different methods of pollinating tomatoes, the relative value of pollinated and unpollinated plants based on earliness and total yield, the labor cost of pollination under different methods, and the net results of pollination.

159. **Fertilizer Tests for Strawberries**, Gordon G. Brown. This bulletin presents the results and recommendations from three years tests with green manure, barnyard manure, and commercial fertilizers as fertilizers for strawberries in the Hood River Valley.

160. **The Small Irrigation Pumping Plant**, W. L. Powers and W. J. Gilmore. Reports the cost, value, and profit from irrigation with small irrigation pumping plants, used for a number of years at the home Station and at branch stations. Design, installation, and operation of pumping plants are briefly discussed.

161. **Duty of Water in Irrigation**, W. L. Powers. This bulletin points out the factors affecting duty of water, discusses Oregon methods for duty of water investigations, and gives a summary of twelve years of study of irrigation and water requirements for different crops under field conditions. Experimental results showing the influence of manure, rotation of crops, and irrigation on water requirement, are reported.

162. **Pear Harvesting and Storage Investigations**, C. I. Lewis, A. E. Murneek, and C. C. Cate. This bulletin follows Station Bulletin 154 in reporting progress on investigations started in 1917. It reports studies and results on the following subjects: (1) increase in size of Bartlett Pears; (2) the "Pressure test," as a measure of maturity of the pear; (3) influence of time of picking and type of storage upon keeping qualities of Bartlett pears; (4) effect of various types of storage upon the keeping qualities and eating qualities of Bosc pears.

163. **Sulfur as a Fertilizer for Alfalfa in Southern Oregon**, F. C. Reimer and H. V. Tartar. This bulletin reports results of seven years experiments in the use of sulfur as a fertilizer for alfalfa in Southern Oregon. Results from sulfur in comparison with results from other fertilizers; results from the use of different sulfates; the results from sulfur on different soil types, and effect of sulfur upon the growth and composition of alfalfa, are discussed.

164. **The Soils of Jackson County**, H. V. Tartar and F. C. Reimer. This bulletin reports chemical analyses of the principal soil types of Jackson county as determined by the soil survey of the United States Bureau of Soils. Based upon these analyses and available data from fertilizer experiments and information as to agricultural practices, suggestions are given as to ways in which the Jackson county soils can be made more productive.

165. **Finishing Pigs for Market**, E. J. Fjeldsted and E. L. Potter. Results over a number of years from experiments in finishing pigs for market at the Corvallis and Union stations are reported in this bulletin. The preparation of many different feeds, and different methods of feeding are briefly discussed. The feeds generally used in the Northwest and these with supplemental feeds are discussed, miscellaneous feeds are commented on, and attention is directed to important considerations in balancing rations.

166. **Fertilizers for Oregon Orchards,** C. I. Lewis, G. G. Brown and F. C. Reimer. This bulletin discusses the general situation as regards maintenance of fertility in Oregon orchards, points out the necessity of analyzing local conditions before deciding to use fertilizers, and reports experiments by the Oregon Agricultural Experiment Station over several years in the use of fertilizers and shade crops in orchards. Special reports of nitrogen fertilizers for fruit trees in the Rogue River Valley and of nitrate of soda for bearing orchards in Hood River Valley are included.

167. **Improvement and Irrigation Requirement of Wild Meadow and Tule Land,** W. L. Powers and W. W. Johnston. This bulletin reports five seasons experiments with tanks and diked fields, with water controlled by drainage and irrigation pumping plants, to determine the water requirement of wild meadow land and the possibility of increasing production on such lands by drainage and better use of water. The results show that by control of water, some water storage, systematic irrigation and drainage, the greater part of such lands, of which there are over one-half million acres in Oregon, can be made to produce double the crops with about half the water formerly used.

168. **Survey of Typical Oregon Farmers' Creameries,** Eric Englund. This bulletin presents data and conclusions from an historical and statistical study of seventeen farmers' creameries located in the Willamette Valley and in the Coast Region, covering the principal butter-producing sections of the State. The various factors which contribute to success or failure of such creameries as determined from this careful study of each of the seventeen creameries are discussed.

169. **Insecticide Investigations,** A. L. Lovett. This bulletin discusses (1) the comparative toxic effectiveness of basic and acid lead arsenates; (2) calcium arsenate and nicotine sulfate as poison insecticides; (3) the physical improvement of poison insecticides by the incorporation of a spreader in the spray solution; (4) the application of these findings to codling-moth control.

170. **The Gray Garden Slug,** A. L. Lovett and A. B. Black. Discusses life-history, habits and injury by garden slugs and includes results of investigations on improved control methods. The recommended control consists of a combination of the use of a poison bait and a repellent spray. The repellent spray recommended for application to the plants to be protected is a dilute bordeaux solution. The most attractive and effective poison bait consists of chopped-up clover or lettuce leaves with the addition of calcium arsenate as the poisoning agent.

171. **The Spray Gun vs. Rod and Dust in Apple Orchard Pest Control,** Leroy Childs. This bulletin discusses mainly (1) the dusting methods versus the liquid method of spraying; (2) the spray gun vs. the spray rod; (3) the high-powered modern equipment vs. medium or low-powered equipment as to relative degree of codling-moth control obtained and economy in dollars and cents and in labor. Data are given on cost of effective spraying in Hood River orchards, and for the average usage of spray per tree per application for maximum pest control. The bulletin is based upon four years of experimental study and practical tests.

172. **The Western Pine Bark-beetle**, W. J. Chamberlin. Includes results of original investigations and compiled data bringing information on the pest and its control up to date.

Soil Survey of Yamhill County, A. E. Kocher, E. J. Carpenter, C. V. Ruzek, and J. E. Cooter. (In cooperation with the U. S. Bureau of Soils, Published by U. S. Department of Agriculture.) This report contains a soil map showing each soil type in color, a description of each soil type and recommendations for the management of the important soil types.

The following are in manuscript form ready for publication:

173. **The Irrigation of Potatoes**, W. L. Powers and W. W. Johnston. This manuscript reports twelve years experiments in the irrigation of potatoes. The time, amount, and frequency of irrigation, the water requirement of potatoes and the influence of irrigation, crop rotation and fertilizers upon the crop are discussed. (Published October 1, 1920.)

174. **Fattening Steers**, E. L. Potter and Robert Withycombe. Reports results of six years feeding tests in fattening steers. Results from feeding alfalfa hay alone, chopped alfalfa, alfalfa hay and grain, and alfalfa hay and silage are presented. Results with silage show remarkable gains. (Published October 1, 1920.)

175. **Fattening Lambs; Shelter vs. Open Lot**, E. L. Potter and Robert Withycombe. Reports three years results of fattening lambs with shelter sheds as compared with fattening in the open. The amount of feeds used and daily gains are given. (Published October 20, 1920.)

Station Circulars

21. **Commercial Fertilizers**, R. H. Robinson. Discusses the inspection of commercial fertilizers under the Oregon Fertilizer Control Law; distinguishes between the agricultural or crop-producing value of a fertilizer and its commercial value or selling price; tells how the plant foods are combined in commercial fertilizers; advises purchase of fertilizers having a total plant-food content of 14 percent or over; gives a method for estimating approximate cost of a fertilizer so as to make comparison between different brands; names certain materials which should not be used in mixed fertilizers; and gives a table showing the guaranteed composition and the composition determined by inspection for each fertilizer sold in Oregon during 1919.

22. **Fruit Grower's Handbook of Apple and Pear Insects**, A. L. Lovett and B. B. Fulton. A terse, popular discussion of the principal insect enemies of apple and pear in Oregon and their control. Excellent illustrations add materially to the value and usefulness of this book.

Technical Papers

The following papers, based upon various Station investigations, were prepared by members of the Station staff for presentation at meetings of scientific associations or for publication in leading scientific periodicals. A number of more popular papers are not included.

"The beneficial action of lime in lime sulfur and lead arsenate combination spray," R. H. Robinson, Jour. Econ. Ent. Vol. 12, Dec. 1919.

"Concerning the effect of heat on the reaction between limewater and acid soils," R. H. Robinson, Soil Science, Volume IX, February 1920.

"Relation of sulfates to plant growth and composition," H. G. Miller, Jour. Agr. Research, Volume XVII, No. 3.

"Irrigation and the Protein Content of Wheat," J. S. Jones, Jour. Agr. Science, Volume X, No. 2.

"Some preliminary experiments on onion smut control in Oregon," H. P. Barss. Read before Pac. Div. Am. Phyt. Soc., Portland, Oregon, April 1919.

"Studies of Verticillium wilt of potatoes," by M. B. McKay. Read before Pac. Div. Am. Phyt. Soc., Portland, Oregon, April 1919.

"Preliminary observations on the action of formaldehyde on wheat," W. M. Atwood. Read before Pac. Div. Am. Phyt. Soc., Portland, Oregon, April 1919.

"Some observations on seed treatment injury of wheat," J. P. Rose. Read before Pac. Div. Am. Phyt. Soc., Portland, Oregon, April 1919.

"Physiological Effects of Formaldehyde Treatment on Wheat," W. M. Atwood. Read before Pac. Div. Am. Phyt. Soc., Seattle, June 1920.

"Heart rot of prune and peach in Oregon," S. M. Zeller. Read before Pac. Div. Am. Phyt. Soc., Seattle, Washington, June 1920.

"Spur blight of pear caused by Botrytis," S. M. Zeller. Read before Pac. Div. Am. Phyt. Soc., Seattle, June 1920.

"A Cytospora canker of apple," S. M. Zeller. Read before Pac. Div. Am. Phyt. Soc., Seattle, June 1920.

"The First International Potato Disease Conference," H. P. Barss, Potato Magazine, September 1919.

"Uniform rules and regulations for seed potato certification in the Pacific Coast States," M. B. McKay. Read before First Interstate Vegetable Growers' Conference, Riverside, California, May 1919. Published in California State Comm. Hort. Mo. Bulletin 8:288-291, June 1919.

"Verticillium wilt of potatoes in Oregon," M. B. McKay, Potato Magazine, 2: No. 6. (5 figures), December 1919.

"New Oregon Diptera," A. L. Lovett and F. R. Cole, Proceedings California Academy of Science, Vol. VII, No. 2.

"Catalogue of Oregon Diptera," (Systematic), A. L. Lovett and F. R. Cole, Proceedings California Academy of Science, (in press).

"Spreaders in the Spray Solution as an Aid in Efficient Codling Moth Control," A. L. Lovett, 15th Annual Washington State Horticultural Society, page 7.

"The Use of Spreaders in the Spray Solution," A. L. Lovett, Oregon Grower, April 1920.

"Notes on Two Little-Known Wood-boring Coleoptera," (Systematic), W. J. Chamberlin, Journal N. Y. Ent. Soc. XXVIII, pages 151-157.

"Description of One New Buprestid with Notes on other Little-Known Species," (Systematic), W. J. Chamberlin, Ent. News. (In press.)

"A Revision of the Buprestid Genus Poecelionota with descriptions of New Species" (Systematic), W. J. Chamberlin, Jour. N. Y. Ent. Soc. (In press.)

"Some Observations on the Color Changes of the Diphenylamine Reaction," E. M. Harvey, Journal of American Chemical Society, June 1920.

"Prepotency," L. W. Wing, Jr., Western Breeders' Journal, June 17, 1920.

"Sulfur in Relation to Soil," W. L. Powers, U. S. Reclamation Record, Number 1, page 28, 1920.

"Some Observations concerning Abortion Disease," B. T. Simms. Read before Joint Meeting of Oregon and Washington Veterinary Medical Associations, 1920.

Extension Bulletins

Number	*Title*
224	**Orchard Spray Program,** H. P. Barss.
226	**1918 List of Growers of Certified Seed Potatoes,** M. B. McKay.
295	**Seed Potato Certification in Oregon,** M. B. McKay.
228	**Insect Pests of Stored Grains and Mill Products,** Frank H. Lathrop.
282	**Beekeeping for the Oregon Farmer,** A. L. Lovett.
305	**Rational Use of Lime,** Soils department.
319	**Corn,** George R. Hyslop.
300	**How to Cull the Layers,** James Dryden.

In addition to the foregoing, several hundred popular articles by members of the Station staff giving results and suggestions from Experiment Station work, were published in magazines, newspapers, and as circulars of the Extension Service.

INVESTIGATIONAL WORK

A brief statement of the more important investigational work of the Station during the biennium, showing the object and character of each investigation and something as to progress and results, is given in the following pages. The investigations are grouped by Departments and Branch Stations, the Departments representing the work of the home Station at Corvallis. The Departmental reports are arranged with reference to related or similarity of problems.

DEPARTMENT OF ANIMAL HUSBANDRY

The investigational work of the department of Animal Husbandry is carried on at the home Station at Corvallis, and in cooperation with the Eastern Oregon branch station, at Union, where important work has been in progress for several years. The investigations and results at Corvallis are here reported briefly. Results at Union are reported under the branch station.

New Varieties of Silage

New Varieties of Silage. Sunflower silage was compared with corn silage for both lambs and cattle. The stock did not take to the sunflower silage as readily as to the corn silage, but after they were once used to it, ate it just as well. There was no apparent difference in the gains made. The sunflowers made more gains in one test and less in another.

Silage made from corn stover (without ears) proved palatable and satisfactory. It carried much more water and more fiber than silage from ear corn and its value was proportionately less.

Clover straw as a silage material has not yet been used satisfactorily.

At the Eastern Oregon station splendid results were obtained with peas and bald barley silage and with alfalfa and bald barley silage for fattening steers and for wintering calves and yearlings, and for fattening lambs. Large quantities of sunflower and peas and bald barley silage will be put up for tests this coming winter.

Fattening Steers. There has been concluded in cooperation with the branch station at Union, six years work with fattening steers to determine the value of alfalfa alone, alfalfa and a small grain ration, chopped alfalfa, and alfalfa hay and silage. The results are given in Bulletin 174 and are summarized under the branch station.

Cost of Horse-power. The cost of horse-power per hour of all horses belonging to the College was, for 1920, $0.151. Since 1915, when this study was started, the unit cost of feed and labor has doubled, but by better distribution of the work and more careful management, as a result of this investigation, the increase in cost per horse-power has been but 28 percent instead of the 100 percent which would be expected.

Farm Sheep. Investigations on the subject have been under way during several years. It has been found that the secret of farm sheep raising is to have some hill pasture available for late fall and early spring feed so as to shorten the winter feeding to a minimum. A long winter's feed always results in a loss on the year's operation. Native hill pasture has been yielding an average of 249 sheep days per acre annually. Cultivated pastures yield from three to five times this amount, but are more expensive per day. Market lambs that are sold early in the summer can be raised profitably without cultivated pastures, but pure-bred lambs cannot be grown out satisfactorily under Willamette Valley conditions without a cultivated pasture, such as rape, for dry weather.

The June shearing of long-wooled lambs dropped in January and February did not prove as desirable a practice as some farmers assume. The lambs shorn in June did not produce more wool, nor did they make greater gains than those which carried their fleeces through the warm weather. The wool shorn twice a year was shorter in fiber and consequently of lower value, while the cost of shearing and marketing was greater with two shearings than with one.

This material is now being prepared for publication.

Pig Fattening. During the last biennium the following facts have been determined in feeding investigations of the Station:

That four pounds of garbage is equal to one pound of barley. Pigs may be fattened on garbage with but little or no grain. Grain must be fed for the last week or two, however, to keep the pigs from being paunchy.

That fish meal is an excellent supplement in pig feeding and fully equal to the best grade of tankage.

That cocoanut meal may be used as a supplement in pig feeding but that it is very variable in its results. Much work has been done with it and more is in progress.

That pigs getting garbage and rape or wheat pasture in addition to their grain ration do not require a protein supplement.

That on the heavy soils of Benton county, fall wheat sown thick in the spring makes a splendid summer pasture for pigs.

That if runts are separated from the bunch and given plenty of good feed they will make normal gain.

That oats for growing pigs produces a better frame and better legs than barley, but that the difference is slight and the expense justifiable only in case of high-class breeding stock.

That molasses may be used for pig fattening in amount not to exceed 40 percent of the ration and that when so used it has a value nearly as high as barley.

That molasses increased the consumption of an unpalatable ration but did not increase the consumption of a ration of normal palatability.

DEPARTMENT OF DAIRY HUSBANDRY

At present it is estimated that there are more than 200,000 head of dairy cows in the State and that about 22,000 farmers and their families are engaged in the dairy business. The eventual development of the dairy industry in Oregon depends upon the success of the Oregon dairyman in competing with the cheaper butter of the corn belt and the more cheaply produced foreign butter and other dairy products in our own and the world markets. This means that every effort must be made now to economize in methods of production.

The diversity of climate and soil in Oregon makes a different set of conditions for each section of the State. Each section has its advantages and disadvantages. The dairymen of the Coast Region have one set of problems and those of the Willamette Valley another. Those in Southern Oregon have problems still different from the Coast and Valley sections and the dairymen of the irrigated section have a fourth and distinct set of conditions. The problems of management in the northern part of the Coast Region are different from those in the southern part. The white land section of the Willamette Valley because of different crops and of different yields when the same crops are grown gives rise to different problems of feeding and management from those of the more fertile, well-drained upland and the excellent river-bottom land.

Because of these different sets of conditions in the State, the dairy industry presents as many problems to the Experiment Station as if three or four ordinary states were involved. In addition to the practical problems there are indications of those of deep scientific importance. For example, serious nutritional troubles are indicated by reports coming from the irrigated sections where alfalfa is fed exclusively. What is to be done to correct them? To answer such a question requires a careful and sometimes costly study covering perhaps a period of years. But to insure the prosperity of the industry in sections where these troubles occur the answer eventually must be given.

Similarly there is the question of the most satisfactory and economical pasture supplement for the Coast sections and that of the pasture substitute for the Valley. Changing economic conditions call for a complete readjustment all along the line with reference to desirable feeds to use for dairy cattle. New feeds are being introduced and farmers want to know facts about them. New methods of using the ordinary feeds available must be worked out. More and more the dairyman is faced with the fact that he must feed less commercial feed and

more home-grown feeds. When to stop using grain and to depend altogether on roughage is a problem he will eventually face.

Properly to guide the development of this great industry of Oregon, these and many other questions must be answered. And many of them will require fundamental study which can be given satisfactorily only at the home Station where laboratories and the services of specialists are available. The few investigations undertaken and the results secured are given briefly in the following pages.

Raising Calves on Milk Substitutes

Preliminary studies on this project were started during the biennium in the hope of developing a home-grown ration satisfactory for use as a milk substitute in raising calves. Three calves were placed on a meal mixture of bran, ground barley, oil meal and ground clover hay. This trial was run for ninety days. It appears from the preliminary work that: (1) Calves can probably be raised on less milk than earlier experimental work has indicated; (2) the mixture used gives fair results, at least of sufficient promise to warrant further trial; (3) indications are that a calf meal may contain more than three percent crude fibre and still be satisfactory. The calves fed in the trial have since developed as satisfactorily as those fed on skim milk.

The investigations will be continued using 24 calves and four different meal mixtures.

Silage Investigations

Work on this project was started in 1919. Observations were made on the best stage of the oat and vetch crop for silage. When the vetch was in full bloom, the flowers had withered, and the pods had formed, a sample taken and run to air-dry basis showed 24.07 percent dry matter. Fifteen days later, when the blooms on the vetch had practically all withered and the vetch seeds were about half formed in the lower pods, a sample was taken, run to air-dry basis and showed 29.25 percent dry matter. At this stage it was ensilaged and produced excellent feed with, and also without, the addition of water as it was put into the silo. Average corn silage has 26.1 percent dry matter.

Six samples were taken each of corn and sunflower silage as they were put into the silo and acid determinations were made at intervals of three days for the first fifteen days, and the sixth sample was allowed to stand for thirty days. The percent of acid formed varied, due probably to experimental error, but showed an increase up to the sample held thirty days. This was compared with samples inoculated with a "butter culture" of Bacterium Lactic Acidi. One sample was packed and the other left loose. In the packed jars slightly more acid was formed than in the unpacked. Neither the packed nor the unpacked inoculated samples produced more acid than the untreated samples, a fact which seems to indicate that the inoculation of silage at the time of making, with a culture of Bacterium Lactic Acidi, a method given considerable publicity last year, does not increase the amount of acid nor keep the silage in any better condition than when put up by the usual method of cutting and tramping to exclude the air.

A feeding trial to compare oat-and-vetch, corn-and-sunflower silage was conducted. It was found that a change from oat-and-vetch to corn

ensilage or the reverse could be done immediately without any harmful results, but a change to sunflower silage had to be gradual or the cows were thrown off feed. The question of getting the animals to consume sufficient amounts of sunflower silage was one of the principal difficulties encountered. From the one trial there is apparently no difference in the three kinds of silage for cows, in milk, if taken upon the basis of an equal amount of nutrients from each. However, the cows would not eat as much of the sunflower silage as they would of the corn and oat-and-vetch. This may have been due to the fact that the sunflower silage was probably made from more immature plants than it should have been.

Winter Rations for Growing Dairy Heifers

Feeding tests on this problem were started in the fall of 1918. Twenty head of dairy cattle were divided into two groups of ten head each. One group was fed entirely on clover hay, the other group was fed wheat straw, molasses, and a mixture of mill run and cocoanut meal. From this test, covering the period November 21, 1918, to February 10, 1919, it appears that young dairy cattle can be wintered satisfactorily on straw, molasses, and a small amount of grain at a cost of 30 to 40 percent less than that of wintering on clover hay.

Ten heifers from 8 to 19 months of age were divided into two groups of five each. One group was fed 6 pounds of clover hay plus sunflower silage ad. lib. daily and the other group 6 pounds clover hay plus corn silage ad. lib. All of the heifers showed greater tendency to make skeletal growth rather than gain in weight on these rations. They made an average daily gain of .133 cm. in height at withers or 4 cm. per month and an average daily gain of .25 to .7 pound in weight.

The heifers consumed from 3 to 4 pounds of silage for each pound of hay. This study will be continued, using other combinations.

Comparison of Mill Run vs. Bran and Cottonseed Meal vs. Cocoanut Meal, for Milk Production

This was a practical feeding test conducted during the winter 1918-19 to furnish information needed as to relative values of the feeds used and preliminary to a more thorough study of feeds and feeding problems under Oregon conditions.

Mill Run vs. Barley. Three groups of three cows each were fed on the following rations: (1) Mill run 300 pounds, barley 300 pounds, cottonseed meal 75 pounds. (2) Barley 575 pounds, cottonseed meal 75 pounds. (3) Barley 575 pounds, cocoanut meal 75 pounds. These mixtures were fed with corn silage and clover hay. It appears from the results secured that barley is a very satisfactory substitute for mill run. The cost of producing 100 pounds of milk was less with the cows receiving the barley ration at the prices prevailing at the time the experiments were conducted. The cows receiving barley did not gain in weight to any greater extent than did those receiving mill run.

Cottonseed Meal vs. Cocoanut Meal. Three groups of four cows each were fed the following rations: (1) Mill run 200 pounds, barley 200 pounds, oats 100 pounds, cottonseed meal 100 pounds, cocoanut meal 100 pounds. (2) Barley 300 pounds, oats 100 pounds, cottonseed meal

100 pounds, cocoanut meal 100 pounds. (3) Mill run 200 pounds, barley 200 pounds, oats 100 pounds, cocoanut meal 200 pounds. These are more complicated rations suitable to cows on official test. The roughage feed was clover hay and corn silage. Ration Number 2 containing the 300 pounds of barley produced the greatest amount of milk. The lowest cost of production was from ration Number 3 containing cocoanut meal. After cows become accustomed to cocoanut meal it can be used successfully to replace a certain proportion of cottonseed meal.

DEPARTMENT OF POULTRY HUSBANDRY

POULTRY BREEDING

Inheritance of High Egg Production. That high egg production is inherited is one of the important findings of our breeding work. Selection of breeding stock by their actual trap-nest records for a number of years has resulted in a definite increase in production.

In the first year of the work, 1908-09, the flock average of the Barred Plymouth Rocks was 86.14, and of White Leghorns 106.88 eggs. In that year only one hen laid 200 eggs. Since then there have been developed in other breeds, flocks that average 200 eggs or more, and 1200 individual hens have laid 200 eggs or more in one year. Nine hens have laid 300 eggs or more in a year. All have been developed from the original flock.

The results, which have already secured considerable publicity, have been a stimulus to poultrymen to pay greater attention to breeding, and commercial poultry keeping is now a safer and more profitable industry.

To determine what effect, if any, climatic or other local conditions may have had on the result, pens of our fowls have been entered in laying competitions in various states. They have done practically as well as at home, and have won first place in several contests. In Australia and Canada also, they have shown high egg-laying capacity in official egg-laying contests. The results indicate further that it is possible not only to develop high-producing strains, but by proper management to maintain high egg production.

Study of Type. A study is being made of body type, in connection with our trap-nest records, to determine, if possible, if there is any correlation between high egg production and type or conformation. The purpose of this is to learn whether the costly method of selection by trap-nest can be obviated. A great deal of work has been done in the way of measurements and weighing during the present year. Thirteen different repeated caliper measurements have been made of some 700 hens. This work is not yet completed, and it is not possible at this time to state whether the findings will be of a negative or positive character.

Early Laying Maturity a Sign of Good Laying Ability. A study of our records shows that pullets vary considerably in length of time required to reach laying maturity, and it has been definitely shown that early laying in a pullet is characteristic of a good layer. The records show also that late laying is characteristic of the good layer. In other words, our breeding work has resulted in lengthening the period

of laying both at the beginning and the end of the year. This indicates effective methods of culling or selection without the use of the trap-nest. Just what percentage of accuracy may be obtained by culling at the beginning as well as at the end of the year has not been determined. The records are so conclusive, however, that poultrymen are recommended to cull both at the beginning and at the end of the year. The records also show that high egg production is characteristic of a good layer at all seasons of the year. Even in the months of most favorable production, when the poor layers are laying, a good layer will produce better than a poor layer.

Relation of First Year's Production to Second and Subsequent Years. Our work has shown that good layers as well as poor layers lay more eggs as pullets, or in the first year, than in any subsequent year. A good layer excels not only in the first year, but in all subsequent years, on the average. The effect of our breeding, therefore, has been to lengthen the profitable period of laying of the hen. In other words, laying longevity is largely a matter of breeding. The practical result of this discovery is to reduce the cost of production by obviating the necessity of so frequently reproducing the flock. The costs of incubation and brooding will be materially reduced if the laying flock be kept, say three years, instead of one, or at most two years, as is the case in a flock that lacks the breeding.

Relative Influence of Sire and Dam on the Offspring. Considerable data have been secured on this subject. While a complete analysis has not been made of the records, they indicate that high egg production is not inherited from one parent only. The importance of the male, however, is emphasized as a very practical means of breeding up laying qualities in the flock.

Effect of Inbreeding. Our records indicate that close inbreeding has a very decided effect first, in lowering production; second, in reducing the fertility of the eggs; and third, in lowering the vitality of the offspring. Cross breeding or outbreeding, on the other hand, has resulted in better fertility and hatch-ability as well as better vitality and production.

Meat Qualities and Egg Production. One of the objects of our cross breeding was to determine how far meat qualities and egg production are correlated. From an original cross of Barred Plymouth Rocks and White Leghorns, we have developed a type of fowl that has given us very high egg production. The purpose now is to fix the type about midway in weight between the White Leghorn and Barred Plymouth Rock. The results indicate that a fowl of this size may have laying capacity equal to a Leghorn of small size. If the Leghorn can be increased in size about a pound in weight, and thereby improved in meat qualities, it will be a distinct gain to commercial poultry keepers, and especially to farm poultry keepers, because the farmer who keeps a few hens wants meat as well as eggs.

External Characteristics as an Indication of Laying Capacity. A study has been made of our records which indicates that late molting is characteristic of a good layer, and early molting of a poor layer. It has also shown that heavy egg production results in a loss of the

yellow pigment color in the shanks and beak especially, and it is possible in a measure to judge in this way of the production of the hen.

Breed Improvement. As a result of our breeding work there has been an insistent demand from all parts of this State and other states, as well as foreign countries for breeding stock and eggs for hatching, with the result that the O. A. C. stock is found in every corner of the State, and in most of the other states of the Union. It is hardly possible to overestimate the value of the stock in the improvement of the egg production of the flocks. This work is growing, and to attend to it properly more land should be available. More help in the raising of the stock and in keeping up the pedigree books is also necessary.

INCUBATION INVESTIGATIONS

Incubation investigations began in 1908 and continued with a small Adams' Fund allowance until two years ago, when they were discontinued. One bulletin has been published, but a large amount of later data remains to be worked over and prepared for publication. The object of these investigations was to solve some of the problems of artificial incubation, which seriously concern commercial poultrymen.

Effect of Moisture on Hatching. The problem has mainly resolved itself into a study of humidity conditions in the incubator, or the effect of different degrees of humidity both on the hatching of the eggs and on the quality of the chicks hatched. The most striking result of the investigation was the great increase in the number of chicks hatched by the use of a certain amount of moisture. This is a subject that had never been thoroughly studied. Incubators vary greatly in manufacture, and the variation in humidity conditions in different incubators was surprisingly great. In our earlier experiments, by maintaining the humidity condition of the incubators at a temperature of about 88 degrees as indicated by the wet-bulb thermometer, we secured more than thirty percent better hatches than where the air of the machine was dry, or where the air showed a temperature of about 85 degrees by the wet-bulb thermometer. Another result equally important was that the chicks hatched in the moist machine were better than those hatched in the dry. They showed a greater weight when hatched. These results created much discussion among incubator makers as well as incubator users, and resulted in modifications, both in the machines and method of operation. This information has been of great value to the poultry industry.

The effect the use of different degrees of humidity in the machine has on the chemical development of the chicks, was made a subject of cooperative investigations with the Chemistry department of the Station. It was shown very definitely that moisture was really an important factor in the proper development of the chicks. The amount of phosphorus, lime, and certain compounds of protein and even the amount of fat in the chick was shown to be markedly influenced by the amount of moisture in the machine.

Another point that was brought out in the investigations was that the chick during its development within the shell was drawing upon the shell itself for nutrition, or for the necessary mineral elements to make proper growth of frame or skeleton, and with sufficient moisture in the

machine, the chick was able to draw a larger supply of lime from the shell. These discoveries are of fundamental importance in the successful incubation of chicks.

Influence of Ventilation or Fresh Air. The moisture problem is closely interwoven with the ventilation of the machine, and enough work has been done to show that there is a danger in both too much and too little ventilation, but what the optimum amount is, will require further investigation to determine. In cooperation with the Physics department, apparatus was attached to the incubator by means of which it was possible to secure a definite measurement of the volume of air going into the machine under normal conditions, and to note the effect of varying amounts of air on the hatching of the eggs and vigor of the chicks. This is important work, but for lack of funds it has had to be discontinued.

Temperature Conditions. A number of complete records have been secured for the full incubation period of the temperature conditions under the sitting hen, by means of a self-recording thermometer, which gives a continuous record. These charts throw some new light on the temperature conditions in natural incubation.

DEPARTMENT OF VETERINARY MEDICINE

With the increase in the value of the livestock of the State and the increased cost of production, the problems concerning disease are becoming more and more important. It is estimated that infectious abortion and sterility in cattle cost the State more than one million dollars annually. The various animal parasites, especially lung worm and liver flukes, find ideal conditions for their development in Western Oregon. They have made serious inroads upon sheep and cattle production in some sections. Hemorrhagic septicemia of sheep and cattle, walking disease of horses, leg weakness of poultry, salmon poisoning of dogs, and takosis of goats, are a few of the other diseases which are of enough economic importance to demand careful investigation.

The attention of the department during the biennium has been centered on diseases of cattle, mainly infectious abortion.

Infectious Abortion Caused by B. Abortus (Bang)

Investigations under this project were aggressive and much progress has been made. The studies have covered: (1) method of spread of the disease including the feeding of infected milk to calves, the bull during copulation, pen exposure of heifers or cows before conception, and pen exposure during pregnancy; (2) the agglutination test as a method of diagnosis; (3) the significance of maximum agglutinations; (4) the possibility of ridding the infected udder of infection; (5) the possibility of another organism than *B. abortus (Bang)* acting as a causal agent; (6) the possibility of eradicating infectious abortion through testing all the animals in a herd and eliminating all reactors; (7) the possibility of the disease disappearing through building up of herd immunity; (8) the possibility of controlling infectious abortion through the use of carbolic acid.

From the investigations to date, the following conclusions seem warranted:

1. Infected milk may be fed to young heifers with very little danger of their becoming infected.
2. There is very little danger of spreading the disease through breeding negative females to negative bulls which have served positive females.
3. There is very little danger in spreading the disease through pen exposure of unbred heifers.
4. The common and most serious method of spread of the disease is through pen exposure of pregnant animals.
5. It is very probable that an infectious abortion-free herd can be built up from an infected one by adopting herd-management methods which will prevent exposure of any heifers after they have reached sexual maturity.
6. The disease is not self-eliminating in dairy herds handled according to the management methods usually adopted in the Willamette Valley.

A more complete report of the investigations and results will be published soon.

Sterility in Breeding Cattle

In Bulls. Studies of herd bulls have shown that in many herds where breeding troubles are general, the male animals are at fault. Microscopic examination of the semen of eight sterile bulls and about the same number of fertile bulls have indicated that bulls are usually sterile unless at least 85 percent of the spermatozoa are alive and active. In normal bulls, practically every spermatozoon has been active.

Exercise, good care, and rest from breeding has restored the fertility both of bulls which showed a high percentage of dead spermatozoa and of those showing no live sperm cells. Exercise has seemed to be an important factor.

In Cows. Very little progress has been made in studying the causes of sterility in females. No further material has been obtained for bacteriological examination of cystic ovaries. Clinical treatment of these cases continues to result in breeding in approximately 40 percent of the animals. In one cow with a cystic ovary which failed to respond to the usual treatment the diseased organ was removed. The cow has conceived since the operation.

Diseases of the cervixuteri continue to constitute the major number of cases of sterility. Histories obtained indicate that about 20 percent of the animals so affected have had trouble at the previous calving. Treatment of these cases has resulted in approximately 50 percent recoveries.

Vaginitis and Balanitis

One outbreak of a very severe form of ulcerative vaginitis was seen. Evidence indicated the disease had been spread by a mature bull. This animal was suffering from a purulent ulcerative balanitis. He had served six cows and all of then were diseased. Other cows in the same herds with these six were not affected. Pus collected from the bull and introduced into the vaginas of healthy heifers failed to set up the

disease. Bacteriological examination of the pus did not result in the isolation of any causal agent. Three of the six cows so affected are apparently pregnant from the one service by the diseased bull. All the animals have made marked improvement without treatment.

Miscellaneous Work

Anthrax. The first outbreak of anthrax ever diagnosed in Oregon was diagnosed in August, 1919. The material for diagnosis was sent in by Dr. A. G. Moore of Ontario. The outbreak was checked promptly.

Unknown Disease of Cattle in the Fort Klamath District. Five days spent at Fort Klamath studying a disease prevalent there, revealed the following facts:

The disease usually appears in July and lasts until after the fall rains set in. It attacks fat steers most frequently. Mortality is above 90 percent. Animals live from twelve to thirty-six hours after first symptoms appear. Symptoms are loss of appetite, rapid breathing, sometimes bloody dysentery, very dark urine, and bleeding from the nose.

Principal autopsy lesions were marked hemorrhages on all the serous and mucous surfaces, very abundant hemorrhagic peritoneal, pericardial, and pleural effusions, passive hyperemia of spleen, passive hyperemia with infarction and necrosis of liver, and blood that clotted freely.

Seven rabbits and eight guinea pigs were inoculated with various body fluids and organ suspensions with negative results. Thirty-seven tubes of raw serum or blood agar were inoculated. No characteristic organisms were obtained. No diagnosis was made.

Hemorrhagic Septicemia in Cattle. One field trip into the Cascades of Linn county was made to investigate diseases of cattle. Symptoms and autopsy lesions were typical of hemorrhagic septicemia. Rabbits injected with splenic suspension died and the organism was obtained in pure culture from them.

In cooperation with the department of Bacteriology, experiments are now under way, injecting calves with the organism causing hemorrhagic septicemia and studying the effects of these injections.

Hog Cholera. An outbreak of this disease appeared in the vicinity of Corvallis in April, 1920. This is the first recorded outbreak in Benton county in more than seven years. Diagnosis was made and the State veterinarian was notified. The outbreak was controlled promptly.

Infectious Disease of the Respiratory System of Horses. (Shipping Fever.) Soon after the artillery horses were brought on the campus, one was noticed with a cough and a nasal discharge. The disease spread to the horses owned by the College, affecting nearly all animals under eight years of age. Symptoms were cough, purulent nasal discharge, loss of appetite, loss of flesh, prostration, and slight rise in temperature. A streptococcus showing marked hemolytic powers was the only organism isolated from the nasal discharge. On account of lack of time this organism was not studied.

Forage Poisoning in Horses. The Algoma Lumber Co., of Algoma, Klamath county, Oregon, telegraphed for help in controlling a disease

which had appeared among their horses during the last week of February, 1920. About eight horses had died and ten to twelve others were showing symptoms.

Clinical and autopsy examinations revealed symptoms and lesions of forage poisoning, very similar to those recorded in horses suffering from botulism. Alfalfa hay was the only feed which had been given to all the affected animals. This hay was bright and clean and appeared to be of good quality. As soon as its use was discontinued the disease was completely checked. About eight of the affected animals recovered under treatment. Hay was shipped to the College and one horse fed on it for twenty-eight days. A profuse purgation with passage of undigested hay occurred about the fourth day. The animal returned to normal and remained so throughout the experiment.

Graham has recorded outbreaks of botulism in which only a small portion of the feed was contaminated. This was probably the condition in this hay.

Botulism in Fowls. For several years birds have reached the laboratory which showed typical symptoms of "limberneck." Histories usually revealed the fact that the birds had eaten either putrid flesh or spoiled canned vegetables.

In cooperation with the department of Bacteriology, canned corn was inoculated with B. botulinus and after seventy-two hours or more fed to mature hens. Symptoms identical with "limberneck" were produced. Autopsies were identical.

Treatment by washing out the digestive tract with water was followed by very slow recovery in two out of three birds.

Control of Liver Fluke Infestation Through Destruction of the Snails Which Act As Intermediate Hosts. Following the suggestion of Dr. Asa C. Chandler, formerly of the College staff, destruction of snails through the use of copper sulfate has been attempted. Both laboratory and field experiments are under way. While it is too early to report definitely, the solutions up to 1:200000 strength do not seem to destroy all snails in forty-eight hours.

Unclassified. Overy 300 specimens were examined and reported upon at the request of people throughout the State. These cases included both live animals and animals that had died supposedly from disease. All kinds of domestic animals and all infectious animal diseases of the State were involved. Many of the cases required a good deal of time and technical skill for examination adequate to determine the cause of trouble.

DEPARTMENT OF FARM CROPS

Perhaps one-third of the total area in farms in Oregon is devoted to the growing of cereal, forage, and root crops. Wheat alone occupies over one million acres; oats, rye, barley, corn, alfalfa, clover and other hay and forage crops are all important.

The growing of the individual crops and combinations of crops alone or along with other agricultural industries in a way to result in profitable agriculture naturally involves a great many problems for investigation. Only a minor number of these problems are under adequate investigation by the home Station due to lack of facilities and funds. The major features of the work during the biennium July 1, 1918, to June 30, 1920, are discussed in the following pages.

FORAGE CROPS INVESTIGATIONS

(Conducted in Cooperation with United States Department of Agriculture, Plant Industry, Office of Forage Crop Investigations.)

Vetches and Related Plants

Vetch is an important crop in Western Oregon. The Station investigations have solved several varietal problems and launched at least one new successful vetch. Many vetch problems are yet unsolved.

Varietal Trials. A great many vetches have been under comparative trials as to their suitability for Oregon conditions. The most promising at this time are: Common vetch, *Vicia sativa*, Purple vetch, *V. atropurpurea*, Hairy vetch, *V. villosa*, Woolly podded vetch, *V. dasycarpa*, Hungarian vetch, *V. parmonica*, and Tangier peas, *Lathyrus tingitanus*. They present a variety of uses. Common vetch is probably the most valuable all-round vetch. It is useful for hay, silage, green feed, and seed for Willamette Valley conditions. Hairy vetch and Woolly podded vetch show much promise as seed crops to supply sections where winter conditions are quite severe. Purple vetch and Tangier peas are excellent for seed production and there is a good outlet for the crop in California. Hungarian vetch, a new one in the Pacific Northwest, offers considerable promise for forage and seed especially on heavy, rather wet soils such as white land. It is exceptional among the vetches as a bee pasture.

Cultural Trials. Cultural trials including time and rate of seeding with and without a supporting or companion crop are being tried out with Purple vetch, Tangier peas, and on a less extensive scale with some of the others. Purple vetch does best seeded alone early in the fall. A 60- to 80-pound seeding of common vetch with 40 pounds of oats seeded early in the fall is best. With most vetches early fall planting gives best results. Planting in the spring is not so good and to be successful at all must be very early.

Fertilizer and Rotation. Trials to determine the effect of different cropping successions or rotations are under way. Work on the use of land-plaster on vetch is being continued without much result from its use.

Breeding Work. Hybridization and selection of vetches to develop improved varieties is being followed. Studies of the pollination habit of vetches and of the relation of insects to pollination are being made.

Red Clover

Cultural Experiments. This work centers principally around methods of securing a stand of clover as affected by time and manner of seeding, with and without companion crops. Fall seedings of clover, either with or without a companion crop, often fail to survive. Spring seedings early, with a companion crop, are usually good. Barley and wheat are probably the best companion crops. Late spring seedings, alone, are satisfactory.

Fertilizers and Rotation. The work with fertilizers is principally the use of land-plaster and lime in securing a stand. An application of land-plaster seems to give the clover plants much more vigor; they stand the dry season better than the limed or the untreated plots.

Breeding. A few clover selections constitute the entire breeding work. This field should be greatly enlarged upon by selection and breeding work to increase the yield, to secure resistance to Schlerotinia and to develop a red clover having a corolla tube short enough so that honey bees may cause tripping and a heavier set of seed.

Sweet Clover

Varietal Trials. A comparison is being made of annual White sweet clover, biennial White sweet clover and the yellow flowering biennial clover. The annual White sweet clover does not appear superior to the biennial form.

Cultural Trials. This work is confined to a very limited attempt to get the best seeding method.

Soy Beans

Soy beans should become an important crop. Without inoculation they are not successful. A limited test of varieties is under way and selections are being made to develop earlier maturing soy beans for Western Oregon.

Horse Beans

This crop shows much promise and should be given a thorough trial. It may become a valuable concentrate for Western Oregon.

A varietal trial of winter and spring plantings is being made. Only a few varieties seem winter hardy. Time and method of planting thus far indicate that early fall planting is best. Spring planting must be very early.

Miscellaneous Legumes

Limited trials are being conducted with alfalfa, Burr clover, and several perennial legumes. Alfalfa is a success on sandy well-drained soil. Burr clover does well on hill land for pasture.

Grasses

A number of varieties and selections are being tried out for their adaptability for hay and pasture at different seasons of the year and for seed production. Work is under way to find the best time and manner of seeding grasses and the best methods of handling the crop for seed production. Trials include work with Tall Oat grass, Orchard grass, Meadow Fescue, Kentucky blue-grass, Timothy, Red Top, and several Creeping Bent grasses, Reed canary grass and a number of others. Results indicate that the Willamette Valley may become a grass-seed production center.

The breeding work with grasses is being carried out by plant selection, seeding, and by vegetable division. There are some good lots of timothy, Kentucky blue-grass, Creeping Bent grass, Agrostis canina, Reed canary grass, and Meadow Fescue. The work should be greatly enlarged.

Pasture Mixtures

Pasture problems open an enormous and almost untouched field. A cooperative experiment was started on hill land to determine the adaptability of certain grasses and mixtures to seeding and pasture on the red hill land of the Willamette Valley.

Results show that the rye grasses make an excellent early growth. Meadow Fescue and Smooth Brome grass proved to be very palatable and the former an especially good grower. Of the leguminous crops, Burr clover seems especially promising for hill-land pasture. The seeding of mixtures demonstrated very clearly that to get even a fair stand it is necessary that there be some loose soil in which the grass may get a foothold. Wherever the soil can be scarified or where there is a good bed of dry ash, stands are easy to secure. Otherwise, it is difficult for the grass to get a foothold and overcome native vegetation.

Hay Measurement and Curing

Stacks of hay are being made and at the conclusion of periods of settlement are being measured and then weighed out of the stacks, when the final measurement has been taken. The moisture changes taking place during the curing process are being studied to some extent.

Bales of hay and straw properly protected with burlap to avoid losses in weight are being weighed at regular intervals to determine changes that take place in storage. Differences in weight amounting to as much as seven percent are recorded from the dry season to the peak of the wet season. This has an important bearing on hay-marketing problems.

Silage Experiments

Vetch, vetch and barley, corn, corn without ears, corn and clover straw, corn and sunflowers, sunflowers, and corn and alfalfa are being tried for silage in the experimental silos to determine: (1) their suitability for silage purposes; (2) the best method of making the silage. The moisture content is being followed, and chemical analyses are being made. Sunflower silage has not proved as rich as corn silage. Trials to date show it about equal to silage from corn without ears. Several weeds are being siloed on a small scale.

CEREAL INVESTIGATIONS

Wheat. Twenty-two winter and twenty-two spring wheat varieties are in trial. White winter wheat has given best results for fall planting. Red Fife and Huston are the best common spring wheats. Blue Chaff Club has made good yields.

Cultural, Rotation, and Fertilizer Work. No cultural work is under way because of lack of land, money, and assistance. The fertilizer and rotation work as it affects the quality of the wheat was suspended for 1919-20. Previous work showed that nitrate of soda applied in the spring produced harder wheat with more gluten.

Breeding and Nursery Work. A large classification nursery of some four hundred seventy plantings, together with a breeding nursery of several hundred selections that have been taken from fields from various parts of the State has been built up and continued. The most promising of the varieties and selections have been put into increase rows and the original experiments duplicated.

Oats. Previous trials show Gray winter the best winter oat variety. A spring varietal trial consisting of eleven varieties is under way. Three-grain, Victory, and Swedish Select show the best results.

Corn Experiments. About 20 varieties of corn are under varietal trial. Minnesota No. 23 is an excellent early variety and Minnesota No. 13 has done well for silage.

Flax. A varietal trial is under way to determine the best varieties of both seed and fiber flax. Rates and methods of seeding are being compared and a small amount of fertilizer is being tried out in connection with the development of fiber flax.

Potato Experiments. (Conducted in cooperation with U. S. Department of Agriculture, Plant Industry, Office of Horticultural and Pomological Investigations.)

Some thirty-five different lots of potatoes furnished by the U. S. Department of Agriculture are being grown to find the ones best suited to Willamette Valley river bottom conditions, with the idea of developing foundation seed lots of the very best varieties.

Time of seeding, depth of seeding, methods of cutting seed stock, are being compared in a definite way. Cutting to save the blossom end seems best.

A limited amount of fertilizer is being tried on potatoes, principally with the idea of determining the stimulating effects of sulfur and of land-plaster and to get at the results of an early supply of available plant food. Land-plaster appears to stimulate growth and produce larger yields.

A number of seedlings as well as selections are being tried out. Hill selection is being practiced and diseased plants are being rogued out from the fields in an attempt to produce a better lot of stock.

DEPARTMENT OF SOILS

The department of Soils is primarily responsible for soil fertility investigations, soil surveys of the State, irrigation investigations, and drainage investigations. Attention has been centered primarily upon the many first problems throughout the State for which there is need for immediate information as a guide to agricultural development and practice rather than upon the more fundamental investigations which are needed and should be undertaken without much further delay.

SOIL FERTILITY INVESTIGATIONS

Fertility Rotations

The rotation experiment at Corvallis with clover, grain, potatoes, beets vs. alfalfa in a four-year rotation has now been continued for twelve years. With irrigation there has been more root growth as well as top growth, and accumulation of organic matter is found to be one-half to one percent. A three-year rotation with grain, alsike clover, and beets has gone through two three-year courses. The crop value of beans following clover sod has exceeded the crop value of beans grown continuously by $30.00 per acre without irrigation and $38.00 per acre with irrigation.

Additional rotations started at Corvallis in 1915 and cooperative trials elsewhere show small differences due to the different rotation treatments. Crop rotations in cooperation with branch stations are reported under the separate stations.

Fertilizer Experiments

Fairly complete fertilizer trials are now in progress on sixteen different soil types of the State. Whether fertilizers should be used of course depends upon their cost and the increase in crop value secured from their use. Certain fertilizers for certain soils have proved profitable and their use more extensively seems warranted.

Phosphorus. Super-phosphate has proved beneficial and profitable on red hill soils of Western Oregon and is now being used commercially on red hill soils of Clatsop, Clackamas, Multnomah, Douglas, and Jackson counties and for potatoes and onions on sandy and peat soils of the Willamette Valley. Studies are being made of utilization of phosphorus in soils of high iron content. Lime, sulfur, manure, and rank-feeding crops are being used in these tests. Our acid marsh soils give indication of benefit from applications of available phosphate. Granite soils and some others in Southern Oregon and sedimentary soils of the lake region are below average in phosphorus as shown by feasibility surveys of proposed reclamation projects in these regions.

Sulfur. Sulfur has been found by Superintendent Reimer of the Southern Oregon branch station to be a limiting element in legume production for certain soils of Rogue River Valley and was simultaneously found to be profitable in alfalfa production in the Deschutes Basin by Professor Powers. Fertilizers other than those carrying sulfur have given little increase in Southern Oregon, and on certain rich loam soils there alfalfa has not responded to application of sulfur. Analyses show certain of these surface soils in the Deschutes Valley, the Umatilla Basin, and in Southern Oregon to contain sulfur sufficient for only ten to eighteen average crops. During a period of five years, sulfur has doubled the yield of alfalfa when applied in experiments in Goose Lake Valley. It has given from one to two tons increase an acre a year in experimental trials in Deschutes Valley, extending back to 1912; and an average increase of nearly two tons an acre annually has been secured in Klamath Basin during the past three seasons. Definite increases in yields have been obtained in Grande Ronde, Wallowa, Baker, Umatilla, and Malheur Valleys. It can be safely said that the experiments over the State have proved that sulfur will increase the yield of alfalfa by at least one ton an acre on at least one hundred thousand acres of alfalfa land in Oregon.

Sulfur and gypsum even with manure have not proved beneficial on the coarse soil at the Hermiston station. Inoculation is being tried there to aid such applications and the sulfur content of the water used is being determined. Experiments this season are showing positive benefits from sulfur applied to field peas in the Klamath Basin, and to corn and beans in Southern Oregon. Reports of definite increases on vegetables and protection from crop pests are coming from the Columbia Basin, where sulfur has been used.

Potash. This element has given little indication of increase in yield on marsh soils, so far as tried. Some increase was secured from the use of potash on deep peat of Klamath marsh the past season. Most of our marsh lands contain considerable potash, received with the silt inwash from the surrounding uplands. Residual soils in the Deschutes Basin are somewhat below average in this element and experiments

have given profitable increases from its application on potatoes. Different commercial forms of potash fertilizer are being applied to potatoes at different rates on four farms in Deschutes county, to determine the most economical treatment.

Nitrogen has proved helpful for non-legumes on many of our field crops. The use of legumes will usually be a more constructive and more profitable treatment than applications of commercial nitrate, except as a starter, wherever rainfall or irrigation will make it possible to secure this element from the inexhaustible supply in the air by means of nitrifying bacteria and legumes. Cooperative experiments show that in establishing legumes under new conditions, especially alsike clover and timothy on the marsh lands, inoculation has helped. Inoculations have helped, for instance, to establish alfalfa under severe conditions, as in the upper Deschutes Valley.

Ground Limestone has been furnished by the State Lime Plant to the amount of about three thousand tons. It is needed to correct soil acidity in the more humid sections. Definite results from its application are more certain in the most humid sections and on the red hill lands in the lower Willamette, and the Coast Region. Lime may be expected to benefit soils known to be acid, or which possess only medium fertility for legumes such as clover. On the home Station farm at Corvallis, nine-tenths of a ton increase in hay yield an acre was secured from limestone where vetch was grown.

Organic Manures. Manure used in experiments at Corvallis and at Hermiston has returned a profit of $2.50 to $10.00 per ton. Nearly all the land in Oregon is benefited by increase in organic matter. The use of stable manure once each rotation in a good system of crop rotation with clover or alfalfa will maintain a good supply of active organic matter in the soil, where moisture conditions are favorable as in the humid or irrigated sections. Stable manure tends to increase the supply of nitrogen. Land in humid sections should be supplied with a winter cover crop such as vetch. Rye and sweet clover are valuable on dry or alkaline lands for the green manure they produce.

Additional experiments with manure are planned.

SOIL SURVEY

In cooperation with the United States Bureau of Soils, field work for the soil survey of Josephine and Multnomah counties was completed during the latter part of the season 1919 and some work was done in Benton county. The survey of Benton county will be completed and field work started in Clackamas county during the 1920 field season. These counties are mapped in detail, except the land included in natural forest. Detailed soil surveys have now been made of about one-fifth the agricultural land of the State and reconnaissance soil surveys have been made of about one-third of the agricultural land in the State. These surveys are regarded as of fundamental importance. They serve as an invoice of the agricultural resources, form a basis for consistent soil investigations, and give a basis for recommending soil improvement and management to farmers.

SOIL CORRECTION TRIALS

Soil correction trials with the white land and the "black sticky" lands have been continued. Applications of lime, manure, green manure, and combinations of these have been given to the drainage experiment field at Corvallis and studies in lysimeter tanks will check the field tests. Quicklime and manure have given some returns in the improvement of black sticky soils. Experiments on white land indicate that the use of manure, legumes, deep plowing, and probably lime will improve the physical condition of this land and facilitate the entrance of water, so that the drainage of these lands may be successful and profitable.

SOIL MOISTURE STUDIES

Soil moisture studies have been extended in cooperation with the Moro branch experiment station and the branch experiment station at Burns. Important soil moisture studies are also carried on at the Umatilla branch station. Important moisture points for the main soil types under irrigation are being determined. A new moisture equivalent centrifuge with which to extend these tests has been secured and is being installed. Records of soil moisture conditions throughout the growing season are kept on the irrigation plots and on the tillage and rotation plots at Burns. Work the previous year developed a number of interesting facts. These are recorded in special reports.

DUTY OF WATER INVESTIGATIONS

Duty of water and related investigations have been continued on the experiment fields at Corvallis, Hermiston, Burns, and on the cooperative fields in the Deschutes basin and Klamath Basin; and duty of water and irrigation trials have been added on the soils field near Medford. Preliminary trials near Medford showed a five hundred percent increase in crops with the use of irrigation on the heavy adobe soil, where many farmers have questioned the feasibility of trying to irrigate. Definite results as to reasonable duty of water for wild meadows were published in Station Bulletin 167.

Results of ten years experience as to the highest possible duty of water under good, modern methods of irrigation farming, based on the water requirement of the plots giving the highest profit an acre, were published in Station Bulletin 161. Based upon this information it takes three inches of water to produce one hundred bushels of potatoes, and five to six inches to produce a ton of hay, so that the duty of water is not likely to be less than fifteen or eighteen inches for a three-ton hay country, or thirty to thirty-six inches where the yield is six tons an acre. Duty of water trials on which to base a reasonable duty of water according to the need of the soils and crops in these sections, have now been conducted five years in the Harney Basin, three seasons in Klamath and Deschutes basins, several years at the Hermiston branch station, and twelve years at Corvallis.

The effect of manure, crop rotation, and fertilizers on irrigation requirement; the effect of irrigation on bacterial activity, accumulation of organic matter, and quality and ratio of plant parts are included in connection with these studies. The wilting point of different crops, and the moisture point at which irrigation should be applied are being studied

by plots supplemented by tank tests. These studies have pretty definitely established the fact that for our brown silt loam, meadow crops should be irrigated when the moisture content drops to the fifteen percent point, dry weight, while for cultivated crops, like potatoes, water should be applied at the twenty percent point, there being a difference in the wilting point of these crops with this soil.

FEASIBILITY SURVEYS

Preliminary feasibility soil and agricultural surveys including sixteen irrigation projects, covering 255,000 acres, and twenty-seven drainage projects and districts covering 100,510 acres, were made during the biennium. Farm drainage systems were designed or surveyed on eleven farms with an area of 500 acres, and irrigation pumping plants for distribution systems were laid out on six farms with an area of 320 acres. The surveys established the merits of reclamation for over two hundred thousand acres of land, which will be doubled in productiveness thereby. The majority of these projects have been organized as reclamation districts.

DEPARTMENT OF AGRICULTURAL CHEMISTRY

INVESTIGATIONS

Chemical Investigations of Acid Soils. Some acid soils of Oregon show increased crop growth when treated with lime while others do not. This investigation seeks the reason for the difference and a more satisfactory treatment for those which do not respond to lime. Of five soil types under study, two which do not respond to lime treatment are found to be weak in their nitrifying power as compared with the three which do respond by increased crop growth. Pot tests with different fertilizers have shown that readily available phosphorus increases the nitrification in the first two but fails to do so in the three which respond to lime. It would seem that the added phosphorus either makes good a deficiency of this element in the two soils or overcomes a normally toxic condition. Attempts to differentiate the two kinds of soil on the basis of phosphorus in their content of organic matter have not yielded positive results. Pending further investigations lime and phosphorus rather than lime alone are recommended for the treatment of the acid soils which do not show increased crop growth from lime alone.

Physical Properties of Insecticides. Field experience has shown that high-grade insecticides practically identical in chemical composition vary in effectiveness because of differences in their physical properties. This investigation, well along toward completion, will enable fruit growers to choose between commercial brands of insecticides on the basis of their physical as well as their chemical properties.

Chemical Investigations of Insecticides. The chemical reactions that occur in lime-sulfur lead-arsenate combination spray were studied under this project. It was found that when lime-sulfur, diluted for summer spraying, is mixed with lead hydrogen arsenate, the active insecticidal and fungicidal properties of the combination spray are decreased appreciably. Under these conditions about fifty percent of the polysulfide sulfur reacts with the arsenate of lead to form sulfide of lead and soluble

salt of arsenate. Since the efficiency of both spray materials is diminished when combined in this manner, it is important that some substance be added to prevent, if possible, the chemical changes which occur. The addition of slaked lime to the lime-sulfur proved efficacious. Analyses of a mixed spray to which slaked lime had been added showed no arsenic in soluble form and very little change in the polysulfide content. For the lime-sulfur lead-arsenate spray, the addition of lime at the rate of ten pounds for each one hundred gallons of solution is recommended.

Sulfur as a Fertilizer. On some soils in Oregon it has been found that sulfur used as a fertilizer brings about remarkable increase in the growth of alfalfa and red clover. This investigation seeks an adequate explanation for the influence of the sulfur as a fertilizer and its effects upon plant composition. The use of sulfate sulfur with nitrate nitrogen in controlled cultures of soils and sand outdoors and in the greenhouse resulted in the formation of larger amounts of true protein in clover than was the case with clover grown under field conditions with and without sulfate in Jackson county.

In soil that was first sterilized and then inoculated with legume bacteria and limed and fertilized with sodium sulfate or calcium sulfate the influence of sulfur was not noticeable in the formation of larger amounts of true protein or of total nitrogen. The explanation of this difference in results from those secured in the first mentioned series is believed to be in the much slower growth. The inference is that a sulfur fertilizer would be most potent in increasing protein formation in legumes under conditions that make for rapid growth.

In the last-mentioned series of pots the influence of sulfur on nodule formation was especially noticeable. In all cases except as noted in the preceding paragraph, sulfur fertilization under controlled conditions has made for larger amounts of total nitrogen in the legumes used. The crops of rape and oats have not yet been analyzed.

The above investigation has developed another fact of importance. Approximately only 60 percent of the nitrogen compounds of clover and alfalfa cut for hay are true proteins. The other 30 percent may or may not have the same value for feeding purposes—as, for example, for milk production in the feeding of dairy cows. Feeding experiments to determine this point should be undertaken.

The Isolation and Study of Pure Proteins from Forage Crops. A pure protein has been isolated from alfalfa seed. By similar methods, attempts are being made to isolate pure proteins from alfalfa and clover cut for hay. Not until the character of these compounds is definitely determined, can these legumes be used to best advantage in the feeding of livestock.

The Composition of Legumes. The legumes produced in Oregon are to a certain extent distinctive. From the analytical work of the past year we are in a position now to say what demands these crops make on the soil for the elements of plant food, and, on the basis of composition, their relative values for feeding purposes.

Yellow Berry in Wheat. Wherever Turkey Red is prominent as a winter wheat the question of quality of grain becomes an important one. The National Grain Standards Act penalizes the producers of

yellow-berry wheat some three or four cents per bushel. In Wasco, Sherman, Gilliam, and Morrow counties there is too much yellow berry in the winter wheat. Investigations recently started in cooperation with the Sherman County branch station, at Moro, aim to find the cause and the remedy of yellow berry. No definite recommendations are possible at this time.

The Home Manufacture of Sirup from Sugar Beets. The unreasonably high price of sugar during the year turned the attention of many persons to possible sources of a cheaper sweetening agency. Laboratory experiments in the making of sirup from sugar beets were undertaken in 1919. It was found that sirup can be made with comparative ease with apparatus any housewife would have at hand in her kitchen. The sirup easily obtained, however, is somewhat objectionable because of the bitter taste it leaves in the mouth. A perfectly good sirup can be made if certain processes are employed. The time and labor involved in making a really palatable table sirup on the farm from sugar beets are believed, however, to be too great to permit the operation becoming a practical one.

OTHER WORK

Cooperative. In cooperation with the Bureau of Soils of the Federal Department of Agriculture, the Soils department of the Oregon Experiment Station is making a soil survey of the leading agricultural counties. In connection with this work it appears best to establish for the various types of soils mapped their potential values from the standpoint of plant food elements. The chemical work is done by the department of Agricultural Chemistry. The major types of two counties have been completed during the year.

Enforcement of Control Measures. To insure the safeguarding of horticultural and general farming interests in the use of commercial fertilizers and lime, 116 samples of fertilizers and twenty or more limestone and land-plaster samples were analyzed during the biennium, and inspections of dealers' stocks were made. For the most part the quality of fertilizers sold within the State is in accord with statements issued by the manufacturers. It became necessary, however, to take rather drastic action against one firm to secure complete compliance with the State law.

Analysis of Miscellaneous Samples. During the biennium more or less complete analyses have been made for people of various parts of the State and other departments of the Experiment Station, of 298 miscellaneous samples of water, milk, food, feeds, fruits, silages, minerals, fertilizing materials, soil, and miscellaneous materials.

Referee Work. In the interest of accuracy in the chemical analysis of insecticides and fungicides, cooperative work with the referee appointed by the Federal Insecticide and Fungicide Board has been done on samples sent out by him during the past year to test the applicability of recommended methods. Approximately three weeks of one man's time was given over to this work.

DEPARTMENT OF BACTERIOLOGY

There is a serious dearth of knowledge of problems of a bacteriological nature throughout Oregon and the Pacific Northwest due to the lack of consistent, continued investigations of a fundamental nature. Bacteriologically speaking, conditions are unknown, data are lacking, while the topographical, climatic, and soil conditions throughout the State are such that the experimentation and experiences in other states lose their significance in solving many problems in Oregon.

Unsettled conditions and changes in personnel incident to the war resulted in temporary discontinuance of investigational work by the department of Bacteriology. During the summer of 1919, however, the department was reorganized and investigational work reestablished with almost an entire change of staff. No projects were carried over, but the other activities of the department were continued. The following projects and miscellaneous work were undertaken.

Microbiological Study of Certain Oregon Soils Having an Acid Reaction. The object of this investigation is to supplement investigations on this problem by the departments of Agricultural Chemistry and Soils in a further attempt to find the reason why certain acid soils respond to lime treatment while others do not, and to work out satisfactory treatment for acid soils in question because of their importance in the permanent agriculture of the State.

Preliminary tests in ammonifying, nitrifying, and nitrogen-fixing powers of both acid and basic soils have been made, bacterial counts determined, and other tests made to make sure that a real problem exists. The project has been outlined and the first experiments started in the greenhouse, but they have not advanced far enough to produce results.

Hemorrhagic Septicemia. Preliminary experiments in a small way have been conducted during the past year and are still in progress on this problem in cooperation with the department of Veterinary Medicine. To date the studies have been concerned with the channel of infection, immunity after vaccination, and with Hemorrhagic Septicemia vaccine prepared by the department. These vaccines appear to be a very important factor in controlling the disease. Many cases are on record in which all vaccinated animals escaped infection, while control animals not vaccinated died. Experimental difficulties and only a small amount of funds and time available rendered progress slow. This disease, however, is causing a loss of livestock estimated at over $100,000 annually and it is hoped that these preliminary investigations can be followed by more thorough studies, in cooperation with the department of Veterinary Medicine.

Cultures for Inoculating Legumes. During the past year, cultures have been prepared and distributed among farmers in amounts sufficient to inoculate approximately ten thousand acres of legumes in the State. In connection with this work considerable study has been given to the preparation of cultures to be sent out. Observations have been made, and more observations are planned, to determine the cause of poor results in the very few cases where the inoculation apparently has not

resulted in the benefits expected. These studies have made possible improvement in cultures so that service to farmers by preparing and distributing the cultures is giving very effective results.

Miscellaneous Work. A considerable amount of clinical diagnosis and sanitary public health work of a bacteriological nature is done by the department of Bacteriology. The importance of correct diagnosis is such that only the services of the most highly trained men in the department, oftentimes members of the Station staff, can be used for much of the work. The total time required for such work during the year approximates the equivalent of half-time for one man.

DEPARTMENT OF ZOOLOGY

The department of Zoology has been represented on the Experiment Station staff during the past two years for the first time and in a limited way only. While there are many problems which might be investigated by the department to the advantage of agriculture in the State, the limited funds and man power devoted to investigations have been centered on studies in the control of damage to agricultural crops by pocket gophers and moles.

The Pocket Gopher. *(Thomomys bulbivorus).* Investigations of the pocket gopher were conducted by the department prior to the work becoming a part of the Experiment Station program and as a consequence, material was available for publication of Station Bulletin 153 issued in 1918. These investigations consisted of (1) life-history studies; (2) nature and extent of damage by the pocket gopher; (3) extensive feeding experiments and observations on feeding habits to determine suitable bait; (4) studies to determine an efficient spreader; (5) experiments in poisoning gophers both in captivity and in the field; (6) methods of placing poison and efficiency of poison. Investigations along these lines have been continued for the purpose of further testing and improving field practice and studying additional species. Attention has been directed to The Dalles gopher, *Thomomys quadratus quadratus*, which differs in habits and requires different treatment from the species studied heretofore.

The more recent investigations show that the pocket gopher is doing much greater damage to agricultural crops, including field crops and orchards, than was previously supposed. Almost every tree over acres of orchard in some localities of the State has been killed by these rodents. The investigation will be continued until methods of control practical for application by farmers have been satisfactorily worked out and demonstrated.

The Townsend Mole. Preliminary investigations have been started for the purpose of working out methods of controlling the damage to agricultural crops by moles. The mole, like the pocket gopher, is doing a great deal of damage throughout the State, and methods of control hitherto worked out are not proving satisfactory. The investigations include: (1) study of the food habits of the mole, data taken from observations in the field, from animals kept in captivity, and from examination of stomach contents; (2) study of the breeding habits of the mole, to determine the time breeding occurs, period of gestation, development and habits of young; (3) experiments to determine an available bait for

poisoning; (4) study of comparative efficiency of traps and their adaptability to various soils; (5) determination of use that may be made of skins as a means of encouraging trapping, i. e., tanning solutions, skinning, stretching, and fabrication.

DEPARTMENT OF FARM MANAGEMENT

Investigations in Farm Management during the biennium were limited through shortage of funds. Studies were conducted, however, on a number of projects.

In cost of production, through cooperation with the Extension specialist, a number of enterprise records, a few complete cost records, and a large number of general financial records were begun.

In farm organization, records were secured for about 500 farms in seven different sections of the State and all computation work on these completed..

In applied farm organization, complete plans have been prepared for about 40 farms of different types and the major share of these plans have been installed.

A considerable study of land-clearing methods was carried out, and additional trials of a new stump burner were made on fir stumps with promising results as to effectiveness and cheapness.

Further studies were made in the housing of livestock for efficient handling and preservation of stock manure. Many shelter sheds have been erected in different parts of the State from plans drawn up by the department and records of their use have been kept.

DEPARTMENT OF HORTICULTURE

The fruit industry of Oregon has grown until it now comprises over 128,000 acres of bearing and non-bearing fruits having a valuation of over $50,000,000. In developing and conducting an industry of this character and magnitude under the varying conditions of the State, there are naturally a large number of horticultural problems, both in the growing of the products and in their preservation and distribution.

The work of the home Station on some of these problems as briefly discussed below, therefore, has a decided economic bearing upon the wealth of the State and upon the welfare of a great many citizens of the State.

PRUNING INVESTIGATIONS

Apple Pruning Studies

The numerous and valuable pruning investigations which have been carried on by the Oregon Agricultural Experiment Station have yielded certain facts regarding the responses of trees to various methods of pruning. It has seemed desirable to study the relation of these facts and responses to the life process of the trees in order to build a more rational foundation not only for future pruning methods, but also for all orchard cultural practices. This has meant somewhat of a change in scope, point of view, and methods of the pruning investigations during the past two years by the addition of detailed physiological studies in the laboratory. Thus far these studies have consisted mainly of biochemical determinations of the food reserves in different parts of the trees as influenced by different methods of pruning already in use.

To furnish material for these studies the following pruning methods were adopted in 1918 and have been continued since:

(1) Heading back in July or August, making the cut into the old wood.
(2) Heading back in June, making the cut into the new wood.
(3) Heading heavily in winter.
(4) Thinning heavily in winter. These last two are probably similar in effect.
(5) No top but severe root pruning (a) in the autumn, (b) in the spring.
(6) No pruning but heavy application of nitrates to soil.

The large general problem is being attacked through specific subproblems. The following will give an idea of the scope, methods, and results to date.

Relation of Carbohydrates and Nitrogen to the Behavior of Apple Spurs. Jonathan, Grimes, and Wagoner varieties were used in this investigation, which has involved studies to determine the effect of spur defoliation on (1) the formation of flower buds and (2) the setting of fruit.

The effect of spur defoliation on the formation of the flower buds was studied by observations on 7000 spurs half defoliated and half used as checks. Defoliation was performed June 16 to June 21, 1919. Samples were collected for physiological chemical analyses July 5 and July 19. Samples of July 19 were examined histologically as well as chemically to determine the number of flower buds initiated for the following spring. It was found that the defoliated spurs formed on an average 57.2 percent as many flower parts as the spurs not defoliated. The chemical analysis showed that defoliation of individual apple spurs tends to throw them into a vegetative or "active" condition, thus increasing their potential for growth, but lowering in proportion their capacity for reproduction. In this the chemical and histological examinations agree. The general results show a high degree of individuality in the apple spur and dependence on its own leaves for its activities, the Jonathan and Grimes showing more individuality than the Wagoner.

During the summer of 1919 about 10,000 spurs were under observation to determine the effect of spur defoliation on the setting of the fruit. Records were kept of the actual performance of spurs under different amounts of defoliation and material was collected from time to time for physiological chemical analysis. The results show a close correlation between the leaf area of the spur and the average number of fruits per spur as well as the average weight of the individual fruit. Again, too, there was strong evidence of high individuality of the apple spur. The chemical results are not so clear, there being little consistent difference in percent of carbohydrates and nitrogen in respect to varying amounts of leaf area of the spur. This is probably explained by the fact that old lignified portions of the spur were used in the analysis. This portion has since been found to be much less responsive than new portions to changed conditions.

The Relation of Carbohydrates and Nitrogen in Apple Leaves to Their Superficial Appearance and to Cultural Treatment. The object of

this experiment is a search for suitable indicators of the internal condition of the tree. Leaf tissue was chosen for study as an indicator since it is easily collected and can be readily handled in chemical analysis.

Three lots of Gravenstein trees were given the following treatments:

(1) Heavy application of sodium nitrate April, 1919.
(2) Check, no treatment.
(3) Heavily root-pruned March 25, 1919, no nitrate.

By June 5, 1919, these plots were already showing considerable difference in appearance among themselves. The leaves of the nitrate-treated were very dark green, those of the root-pruned were smaller and rather yellowish, and those of the checks held an intermediate position. Collections of leaves were made July 26 at which time the difference in appearance of the plots was somewhat more pronounced than in June.

Chemical analysis of the leaves show the following carbohydrate-nitrogen ratio:

Leaves of	*Carbohydrate-nitrogen ratio*
Nitrate-treated	6.03
Check	8.48
Root-pruned	9.98

The results correspond with the effect of spur defoliation on formation of "flower buds," except that they were even more pronounced, the nitrate plot assuming the relative position of the defoliated spurs in having the smallest value of the carbohydrate-nitrogen ratio; the root-pruned trees, the position of undefoliated spurs in having the largest value of the ratio; and the check trees an intermediate value.

This shows that leaves are probably very good indices of the general internal condition of the tree, and if so this fact might later find application in diagnosis of nutritional troubles in orchards.

Tomato Pruning Studies

The object of these investigations was to find in what respect and to what extent pruning can be used to influence the bearing habits of the tomato. This then would give another method by means of which the carbohydrate-nitrogen ratio might be changed in the plant. It was found that:

(1) In respect to number of blossoms and amount of set, the tomato spur cannot be affected very markedly by foliage in close proximity to the spur. It is very possible that a tomato spur, unlike that of the apple, is dependent upon the plant *as a whole* for its carbohydrate supply.

(2) Both pruning and nitrate supply determined amount of growth, blossoming, and setting of fruit of the plant as a whole. Root pruning, even when very severe, had but slight, if any, effect.

(3) Chemical analysis showed a strict correlation between amount of pruning and percent of total carbohydrates in the plant, but no strict correlation could be established between amount of pruning and percent of total nitrogen. All pruned plants were, however, much higher in nitrogen than unpruned ones. Root pruning rather increased than

diminished amount of nitrogen in the tomato. The c/n ratio diminished as pruning increased in amount.

Further studies have shown that blossoms on the tomato will set fruit only when there is a fair amount of foliage on the plant. The removal of leaves almost automatically checks further setting, though there may be an abundance of blossoms present.

FRUIT BREEDING AND VARIETAL TESTS

Strawberry. Fifteen new varieties of strawberries are being tested in comparison with eight older, more established varieties. No new seedlings were produced the past year and all but two promising seedlings of previous years were discarded as unprofitable.

Pollination experiments were carried on with the Ettersburg 121 to determine the cause for complaints as to its light bearing. Six hundred crosses were made with standard varieties and a larger number of flowers were self fertilized. The work is not yet complete for this year. Seed from these crosses will be used to continue the breeding work as carried on in previous years.

Apple. The trees for this investigation were set several years ago but close planting and two dry seasons resulted in weak fruit-spur formation. A large number of the seedlings are bearing this year (1920). A few bore last year, with one giving promise of being desirable. Large numbers were discarded due to damage received from winter injury.

Cherry. The results of records made in 1919 show several seedlings of merit. It was intended to keep records of quantity of production this year, but this was impossible owing to the large numbers of buds killed by the cold temperature. Records have been taken of the relative susceptibility of the fruit buds of the different seedlings, to the severe cold. Also observations have been made for several years on the relative susceptibility of the seedlings to attacks of bacterial gummosis. Tests were made as to self-sterility and self-fertility of eighteen of the best seedlings.

Filbert. This is a new project which has been started in response to the demand for definite information on the best pollinizers for commercial varieties of filberts. Nineteen hundred crosses were made on five varieties using pollen from fourteen varieties. Over 300 flowers were self pollinated on these five varieties for self-fertility and self-sterility studies. Nuts from these crosses will be used to carry on breeding work in the future. Recent inspection shows indications of good results this fall.

Walnut. This work was begun in 1918. In 1919 some 200 crosses were used on various varieties of walnuts. Due to severe damage from winter injury, no work could be carried on in 1920. Records are being kept of relative susceptibility of the different varieties to the cold temperature.

Variety. A few new varieties of various fruits were added to the experimental collection. Records are being kept from time to time on these and others previously received, as to condition, vegetative, and fruiting characteristics. Records are being taken also of the hardiness of different varieties of fruit such as apples, plums, cherries, etc., as indicated by their condition this spring.

Tomatoes

The results of the investigations over a period of seven years were published in Station Bulletin 158 in March, 1919. More than 80,000 blossoms had been under observation. Hand pollination at a cost of three cents per plant has reduced natural unfruitfulness of tomato blossoms from 66 percent to 20 percent of the total flowers produced. The cost of pollination by hand for the entire season is covered by the increased yields in fruit the first two weeks of harvesting. These increased yields during the early part of the harvesting season when prices are high will pay for one-half of the cost of production.

Because of the importance of tomatoes as a spring and summer crop under glass, investigations have been continued.

Comparison of Varieties. Bonny Best (Stokes) has been studied in comparison with Grand Rapids Forcing (Jones). The yield per plant to June 30 was 7.75 pounds for Bonny Best and 4.65 pounds for Grand Rapids Forcing. Two and a half times as much fruit of Bonny Best as of Grand Rapids Forcing was sold at a price of twenty-five cents per pound before the price dropped to twenty cents per pound. The increased earliness of Bonny Best is therefore an important factor.

Comparison of Pollination Methods. Tests in cooperation with Mr. F. B. Chase in his greenhouses at Eugene, Oregon, gave the following results:

Variety	Emasculation percent of fruit set	Spoon percent of fruit set	Tapping percent of fruit set	Check (no pollination) percent of fruit set
	%	%	%	%
Grand Rapids	81	71	68	50
Bonny Best	74	60	55	40

Grand Rapids Forcing showed general superiority in natural self pollination as is shown in the figures where the tapping was practiced and also in the check plants. Bonny Best plants necessitated more regularity and uniformity of artificial pollination to produce a high percentage of fruition.

Miscellaneous Vegetable Tests

Spinach. Spinach planted with cauliflower as a companion crop showed net value for the cauliflower and spinach together slightly greater than for spinach alone, which yielded at the rate of ⅔ of a pound to each square foot or a gross value of 10 cents a square foot.

A crop of spinach was produced after the removal of tomato vines in August. The results show that if seeded about the middle of August, a large crop of spinach can be cut in five weeks yielding at the rate of ¾ pound to one pound per square foot of space used. The crop by virtue of its rapid growth can be marketed in a few days, and the soil seeded again to spinach immediately if desired. In this way three crops of spinach were grown after tomatoes, the heaviest yield being obtained from the fall crop, the second largest from the spring crop, while the winter cutting was inferior to both, due to poor light conditions.

Cauliflower. This crop makes a suitable growth during the later fall and winter months. By planting it at the usual distance of 2x2 feet, it will produce about 5 or 6 cents per square foot. Three varieties, Snow Ball, Gilt Edge, and Erfurt were produced with very little difference between the respective values.

Swiss Chard. In contrast with spinach as a "green" crop, sowed during the winter months, Swiss chard produced at the rate of less than 1 pound to the square foot, and was far inferior to the spinach in rapidity of growth and profit.

French Endive. This vegetable, while not by any means new, was grown for the first time in the Station greenhouse largely for the purpose of introducing it to the trade, both wholesale and retail. The first endive was marketed 23 days after the roots were buried, the average weight of the best roots being about ½ pound during the season. There should be an encouraging future for the sale of this salad plant during the late winter.

Broccoli. Cooperative tests were made in 1919-20 concerning the relative value of the many strains of St. Valentine broccoli now used by growers. Winter conditions of unprecedented low temperatures resulted in freezing many plants in the plots and thus in the loss of much data that otherwise would have been obtained.

In all, thirteen strains were under observation, including five locally (Roseburg) grown strains and six from Northwest seed houses. One strain, also, was grown from seed produced in Clackamas county and one from seed produced in Polk county.

The results show that there is some difference between the earliness of strains of the same variety. One strain gave the largest, earliest cutting; one gave the largest yield; one gave the best quality of heads aside from the damage produced by winter conditions; one strain showed 100 percent freedom from winter injury but the quality was poor.

There is marked difference also in the marketable characters of value in the different strains. The selection of seed from the best strains will lead to larger and better crops of broccoli.

Some twelve strains are again under observation in cooperation with farmers, and the tests are duplicated at Corvallis.

Vegetables Under Irrigation

A series of experimental plots was devoted to the use of water on certain vegetables, the work being a continuation of that begun in 1918-19. Due to the difficulty in getting water at the correct time for application, these tests were not as satisfactory as desired.

String Beans. Three plots of beans were irrigated and one not irrigated in 1919.

The general average gain in yield from irrigation was 16 percent and the largest gain was 31 percent, as compared with yield without irrigation. The summer was dry and water was not available at the proper time for irrigation. The results, therefore, do not show the maximum possible returns from irrigation. The yield of beans in 1918 was 75 percent greater than without irrigation.

Cabbage. Three irrigation plots of cabbage gave an average yield 101 percent greater than the yield without irrigation. The season was very dry for plants unwatered. Cabbage appeared to show greater gain from irrigation than did any other vegetable.

Tomatoes. Three irrigated plots of tomatoes gave an average yield 27 percent greater than the yield of unwatered tomatoes. The largest gain was 37 percent and the smallest 17 percent. Water was not always available for irrigation when it should have been applied.

FRUIT FERTILIZER INVESTIGATIONS

Nitrate of soda at the rate of five pounds per tree was tried in 1919 in two pear orchards including five different blocks representing Bartlett, Anjou, Bosc, and Winter Nelis pears. The soils of one orchard near Roseburg vary from sour clay loam to light reddish hill soil; all soil types of the other orchard near Corvallis are medium clay loam. In the orchard at Roseburg the effect of nitrate upon winter injury was to be noted. This injury was predominant in the sour soils.

The results in all of these blocks show very little difference in length of terminal growth, average size of leaves, color of foliage and set of fruit as a result of the fertilizer during the first season. Two unfortunate conditions, however, should be pointed out. The plowing and subsequent tilling of the soil were either commenced late in the season, or poorly done during the growing season of the year. This practice of itself might result in a poor growth of pears. And there is a possibility that the fertilizer, applied about March 15 and March 25, was put on too late in the season to produce the maximum benefit. The nitrate plots are showing much better fruit buds and set of fruit this year (1920).

Nitrate of soda at the rate of five pounds per tree was scattered broadcast around a block of apple trees of several varieties at Fargo, March 20 to 25, 1919. The soil is of heavy clay tending to white land in places, and although it had been drained, it was too wet for orchard land. The only comparison that showed positive results was seen in the length of new shoots and in the color of the leaves between the treated trees and the check plots. This difference in favor of fertilized plots, was so small, however, that the benefit derived would not pay for the material and labor applied. This test also was not entirely satisfactory because of character of land, tillage, and variation in management conditions.

Nitrate of soda at the rate of five pounds per tree was tried in an orchard of Italian prunes on sandy loam soil at Oakland, and in another orchard at Lookingglass, on light hill soil type in the spring of 1919. Tillage and management in both were such as to give a fair test of the fertilizer. The fertilizer was applied broadcast in each case. A similar test of five pounds per tree was made at Dallas, Oregon, on reddish hill loam soil, light in texture.

The results showed that the trees treated with nitrate of soda had in almost every case responded to the treatment. The effect was more pronounced in the vegetative growth than in the fruit borne, but the results in both vigor and fruitfulness were positive. Yield increased in one orchard approximately one-third.

Nitrate of soda and sulfate of ammonia were tried in comparison, as fertilizers for Cuthbert red raspberries near Brownsville. Both were applied at the rate of 250 pounds per acre scattered broadcast in a strip fifteen inches wide on each side of the row, care being taken to see that the fertilizer did not touch the canes. The berry patch was four years old; the soil medium-heavy river bottom loam; tillage was fair to good; previous crops had been fair, so that the berries were not in run-down condition.

Berries from the fertilized rows were larger, of better color, and matured 3 to 5 days earlier than those on check rows unfertilized. The number of new canes per bush, and their average vigor were much greater on the fertilized rows, and the foliage was darker green and more vigorous. Nitrate of soda gave slightly better results than the ammonia sulfate, but the results indicated that either fertilizer will result in more vigorous growth of canes, darker foliage, and larger fruit.

HORTICULTURAL PRODUCTS INVESTIGATIONS

The installation of equipment in the new Horticultural Products Building was advanced far enough to make possible the starting of a number of investigations during the past year. The products manufactured must be held longer for final examination, and results, therefore, cannot be given at this time. The following statement of problems under study will indicate the character of investigations undertaken and methods of attack.

Clarification and Sterilization of Canned Cider. This study is for the purpose of determining a commercial method of canning sweet apple cider to retain the natural color, aroma, and flavor, the object being to handle the apples so that the juice will be as free from yeast, mold, and bacteria as possible. After canning, the juice is sterilized at different degrees of temperature, and the cans are then incubated to find the correct time of processing. All cans showing signs of quick development of yeast, mold, or bacterial growth are discarded at once, while the others are retained for subsequent careful examination. This experiment was started in October, 1919, but did not progress very far for lack of equipment.

Canning Dried Italian Prunes. The object of this experiment is to make a commercial-canned product that is superior to the home-cooked product. After weighing, soaking, draining, and reweighing the prunes, they were filled into No. 2½ tin cans and given different amounts of sirup ranging from 20 to 40 degrees Balling scale. Cans were then exhausted at 180 degrees F. for six minutes and sealed. After sealing, they were cooked under six pounds of pressure, or a temperature of 231 degrees F., for varying lengths of time.

These canned prunes will be opened during the latter part of 1920 and tested for the following:

(1) Texture, flavor, and appearance.
(2) Selling quality.
(3) Shipping quality.
(4) Economy to compete with prunes in dried form.

Use of Containers for Packing Dried Prunes. This experiment has for its object the comparison of tin, fiber, and damptite containers for the packing of dried prunes, to prevent drying, sugaring, and molding:

(1) Prunes were packed in tin containers (2½) under vacuum, without vacuum, and some sterilized and sealed.

(2) Prunes weighed into fiber containers (plain) and subjected to varying conditions and temperatures. Loss or gain in weight will be noted later.

(3) Prunes weighed in damptite fiber containers and subjected to same conditions and temperature as (2).

Final tests will be made after twelve months to determine the effect of varying conditions and temperatures on quality of the product packed and to find what effect the method of packing has in preventing sugaring and molding.

(The American Can Company of Portland has furnished the containers for conducting this experiment and has been instrumental in assisting in packing prunes under vacuum.)

Canning of Oregon-grown Apples. The object of this experiment is to determine the canning quality of various varieties of Oregon apples in reference to

(1) Quality of the canned product.
(2) Waste in canning.
(3) Methods of canning.
(4) Shrinkage of canned apples.
(5) Cost of canning.

Only a few varieties have been worked with thus far. The cans will not be opened until the goods have stood for a period of twelve months; hence results cannot be given yet.

Dehydration of Fruits and Vegetables. This investigation has been planned to include (1) the effect of lye dipping, blanching, and steaming on prunes to be dried; (2) effect of drying on the sugar, acid, and oil content of various fruits; (3) the effect of air movement, temperature, and humidity on the rate of drying of fruits and vegetables; (4) effect of drying treatments on cooking and absorptive powers of fruits and vegetables; (5) the effect of fruit acid on different kinds of metal screening used to cover trays; and (6) comparison of direct heat and steam heat in drying with reference to rate of drying, quality of product, and the cost of drying per ton.

Problems 1 and 2 were worked on during the year. Further study is necessary, however, before a statement of results is advisable. The dehydration investigations will be pushed as rapidly as possible, as soon as the laboratory improvements and installation of equipment now under way are completed.

MISCELLANEOUS INVESTIGATIONS

Frost Injury Observation. The extreme low temperature which prevailed over most of the State during December, 1919, appeared at one time to threaten seriously the fruit industry. There were many calls for the members of the horticultural staff to visit orchards all over the State and to examine a great deal of material consisting of bark, twigs, buds, etc., sent in to the Station. Much of this material, including samples from 34 different sections of the State, was tested in the greenhouse and suggestions given to growers for the management of their orchards.

Pear Harvesting. The results of the pear-harvesting and storage investigations conducted during 1918 were published in Station Bulletin 162.

The investigations were continued during 1919. Emphasis has been given to further testing and developing of a physical indicator of maturity of the fruit. A "pressure machine" has been designed and made for this purpose. This machine was bought by Jackson county and is now in operation in the county agent's office at Medford. The pressure test was tried with marked success in 1919 on practically all commercial varieties of pears and some varieties of apples. These studies are to be continued in 1920.

During the past year a great many sections of pears in various stages of ripeness were collected and preserved for histological and microchemical studies, in order that a causal reason may be established for the gradual lowering in resistance to pressure of the fruit during the ripening season. Some of this material has been analyzed, but the results are still too inconclusive to be reported here. As fresh material will be at our disposal, these studies will be continued.

A series of storage tests with the Bosc pear was again conducted in 1919, using six different kinds of storage. It was found that "delaying" before placing the fruit in cold storage is a very commendable practice. Properly ripened pears, when stored at fairly low temperatures and a rather high degree of humidity, may be safely kept till the latter part of December. No final solution of the storage problem with the Bosc has, however, been found.

Depth of Planting. Depth-of-planting experiments started several years ago, have been continued. Final examination of all plantings in the fall of 1920 should warrant conclusions and the closing of the experiments.

Filbert Propagation. One of the principal reasons for high cost of filbert stock is the time required for its propagation. This difficulty, it is believed, has been at least partly solved by the experiments during the past year. By taking the young shoot as it comes from the base of the tree and layering it during the first summer, well-rooted plants have been secured during the first growing season. These plants can be started the next year in the orchard. This means a saving of one year over present practice from the beginning of propagation until the stock is set in the orchard.

Weed Eradication by Chemicals. This study was undertaken in the hope of finding a practical means of eradicating weeds that are causing trouble in cranberry bogs. Horsetail fern, bog clover, and fall dandelion are the weeds most troublesome.

Applications for the horsetail fern included: carbolic acid in three strengths from 1 quart to 6 gallons to 1 to 10 gallons; copper sulfate from 1 pound to 2 gallons to 1 pound to 4 gallons; iron sulfate 1 pound to 1 gallon to 1 pound to 3 gallons; arsenite of soda from 1 pound to 6 gallons to 1 pound to 12 gallons. Fifteen sections 2 feet by 4 feet were sprayed, using a small hand sprayer giving a very fine mist spray. The first spray application was given August 20. On August 22 a second application was given except with arsenite of soda, which was applied only once. Final examination was made October 6 to 10.

No results were obtained from the use of carbolic acid and the copper sulfate solutions. The solution of iron sulfate killed approximately 20 percent of the fern but injured the cranberries to an extent of 25 percent, burning off some of the leaves and runners. The arsenite of soda ranging in strength from 1 pound to 8 to 10 to 12 gallons, killed approximately 90 percent of the fern in the strongest form to 40 percent in the weakest, but with the strongest application, fully 50 percent of the cranberries were injured while with the weakest, there was very slight burning of the leaves. With the other arsenite of soda solutions, no noticeable results were obtained.

More time must be given and further research must be made with other chemical substances, before positive beneficial results can be hoped for. Lack of funds has prevented doing this during 1920.

Iron sulfate, copper sulfate, carbolic acid, arsenite of soda, and arsenate of soda were tested as sprays on the bog clover. Only the arsenate of soda gave promise of beneficial results. One pound to 6 gallons killed about 70 percent of the clover without injury to the cranberries; with 1 pound to 8 gallons about 60 percent of the clover, and with 1 pound to 10 gallons about 40 percent of the clover was killed without injury to the berries.

DEPARTMENT OF BOTANY AND PLANT PATHOLOGY

Effort has been directed just as far as equipment and financial resources permitted toward the solution of those problems which have appeared to be the most important in promoting better farming and better fruit growing in Oregon. A good many important problems cannot as yet be successfully approached because of insufficient help or insufficient equipment for the work.

A start has been made on investigations to determine the best means of preventing the statewide destruction due to fruit-tree decay, and fundamental investigations have been begun on certain disorders of orchard trees due to soil and environmental causes which have wrought great havoc in many districts. The last-mentioned undertaking has come to a stand-still, temporarily it is hoped, for lack of funds to secure special equipment needed for further progress. During the biennium the department, through the cooperation of the Federal Government, has been able to serve the interests of the grain growers as never before. Much valuable information has been secured regarding cereal diseases and smut-treatment methods and, more important than all, a number of wheat varieties have been found which are highly resistant or immune to smut. The curtailment of Federal appropriations has threatened the continuance of this work, which should be carried on by all means. Investigations should be started at the earliest possible moment on the perplexing pathological problems which confront the small-fruit industry —an industry already of large proportions that promises to hold a permanent and important position in Oregon.

The work of the department during the biennium is briefly discussed below.

POTATO DISEASE INVESTIGATIONS

Potato Wilt Investigations. For four years experiments have been under way to determine the importance of wilt diseases to the potato industry of the State and to learn to what extent they are transmitted

from year to year in seed tubers and in the soil. The results are being prepared for publication in both technical and popular bulletin form. The information obtained has much practical application in pointing out how growers may select seed potatoes to avoid wilt infection and in showing what length of rotation will be necessary to avoid having the wilt diseases accumulate unduly in the soil.

Potato Storage Rot Investigations. A survey of the causes for, and extent of losses in, stored potatoes was continued during the biennium as time permitted. It has been found that in Oregon the major portion of the potato losses after digging, may be attributed to the attacks of a very small number of decay-producing organisms. The work has paved the way for further investigations which should be undertaken on the control of these troubles.

Potato-seed Treatment Tests. Transmission on the seed tubers of some of the most serious diseases of the potato in the State is largely preventable by seed treatment. Tests have been carried on to determine under local conditions in Oregon the effectiveness of different methods of treatment as recommended in other states. The results have made it possible to recommend for Oregon the corrosive sublimate soak, which has proved so satisfactory and efficient in other states.

DISEASES OF ORCHARD TREES

Physiological Disorders of Fruit Trees. This study was begun in an effort to determine the causes and possible methods of prevention of a serious type of physiological disorder found to be present and important in many Oregon orchard sections. The trouble is characterized by such symptoms as early death of fruit spurs or leaf spurs, die-back of the tops, evidences of a soured condition of the roots or, in final stages, of a sour odor in the sappy bark of the branches. Indications point to the probability that such conditions are related to a lack of oxygen in the soil in many instances. This theory is strengthened by data which have been accumulated showing that under trees exhibiting these symptoms the soil is more acid than under normal trees. It is hoped that the continuance of this investigation may be made possible in order that conclusions may be reached which will give a basis for definite recommendations in orchard practice.

Heart Rots and Tree Wound Disinfection. The fungi causing wood decay in Oregon orchard trees are being determined in an effort to discover those which are most important and destructive, with the ultimate object of concentrating upon them investigations in prevention and control. These wood rots which are responsible for the largest part of the productive mortality in mature Oregon orchards are found to enter through pruning cuts, cankers, areas of bark killed by freezes, and other wounds. Experiments are now under way, therefore, to determine the comparative efficiency of various wound disinfectants and the methods of applying them. Special attention is to be given to the penetration of the disinfectant into the wood at different seasons, the toxicity of the disinfectant to fungi and the effects of the disinfectant on the living bark and cambium during the regenerative healing processes.

Root Rots of Orchard Trees. In order to permit satisfactory investigation of the widespread and destructive orchard disease known as mushroom (Armillaria) root rot, a considerable block of fruit nursery stock has already been planted, in cooperation with the Hood River Branch Experiment Station. The work which is being started will place emphasis on (1) the selection of resistant stocks to replace trees killed by root rot, (2) the susceptibility of graft unions to infection and the general mode of infection, (3) the comparative virulence of strains of the causal fungus obtained from various sources, and (4) possible control measures.

The Underlying Causes for Fire-blight Resistance in Certain Varieties and Species of Pears. Several highly resistant types or varieties of pears have been obtained through the explorations and collections of F. C. Reimer of the Southern Oregon Branch Experiment Station. This investigation has been started to determine what the physical or physiological characteristics may be which account for their resistance as compared with the more susceptible types of pears. It is hoped that this study will lay a basis of knowledge on which may be built a more satisfactory approach to the problem of breeding up blight-resistant and commercially desirable varieties of pears and pear stocks on which Mr. Reimer is working.

Freeze Injury to Orchards, Cankers, and Miscellaneous Troubles. As minor problems relating to orchard health come up they are given attention as time permits. Some attention has been devoted to the effects of the unprecedented freeze of December, 1919. This department gave special consideration to the pathological effects as they developed during the different growth periods of the year. Field studies were conducted in the principal orchard sections of the State and will be continued for the next three or four years so that in the event of another such catastrophe it will be possible to predict with more assurance the ultimate consequences and the chances for recovery in the case of the different fruit varieties. The striking element in the freeze studies thus far lies in the extent of recovery observed in some of the frost-damaged orchards. Aside from the freeze a number of puzzling canker troubles have been studied and several other interesting and possibly important diseases attacking fruit trees, have been given attention.

SPRAYING INVESTIGATIONS

The object of these studies is to determine the comparative value of various fungicides and various spray programs for the control of the commoner and more important fruit diseases of Oregon such as apple scab, peach-leaf curl, apple-tree anthracnose, etc. The purpose is to secure information which shall be a reliable guide to Oregon orchardists in selecting the proper spray materials and schedules to use, and which shall protect them against unsatisfactory, unreliable, or injurious spray materials which may be put forward from time to time. On account of the freeze of December, 1919, this work received a setback at Corvallis due to the death or severe injury of the greater part of the trees in the young orchards used for the tests. Work has been continued, however, both at Corvallis and other points, along the following lines: (a) relative effectiveness of copper sprays and sulfur sprays for peach-leaf

curl control; (b) relative value of different spraying dates for peach-leaf curl control; (c) relative value and safety of various copper-containing sprays and other materials for early applications for apple-tree anthracnose control; (d) relative value and safety of very dilute lime-sulfur sprays, ordinary lime-sulfur, dry lime-sulfur, sulfur dust, and certain copper combinations for apple-scab control; and (e) relative value of different materials for moss eradication on trees.

The results already obtained are of considerable value from a practical standpoint, indicating that bordeaux is superior to lime-sulfur or dry lime-sulfur as a winter spray for peach-leaf curl; that bordeaux is more permanent than any sulfur-containing spray for moss destruction, although not so rapid in action as lime-sulfur plus lye; that in disease prevention dry lime-sulfur may be successfully substituted for the usual liquid lime-sulfur, although the question of relative effectiveness at equal sulfur strength in the dilute condition is still to be determined; that on apples, when prolonged wet weather occurs, injury is likely to occur from the application late in summer of any copper-containing spray yet tested, this being true, at least with Yellow Newtown, even when standard bordeaux is used. Work along these lines must be continued year after year since only after repeated tests to eliminate the effects of seasonal climatic variations and variations in the severity of disease epidemics can safe deductions be drawn.

CEREAL DISEASE INVESTIGATIONS

During the past biennium this department has entered into cooperative relations with the Office of Cereal Investigations of the U. S. Department of Agriculture, which have resulted in the carrying forward at the central and branch experiment stations of a large amount of work on diseases of grain and their control, part of which was conducted by the Federal cooperating investigators H. M. Woolman, C. E. Owens, Miss J. P. Rose and G. R. Hoerner and part by W. M. Atwood of the Oregon Experiment Station. The results of this cooperation have been of immense value to Oregon's grain producers. The reduction of Federal appropriations by Congress has resulted in the forced discontinuance of a good deal of this work, but that on wheat smut prevention and seed treatment is being continued. Following is an outline of the different studies carried on.

Varietal Resistance of Wheat to Stinking Smut. Over a thousand different varieties and strains of wheat have been tested for smut resistance since unquestionably the ultimate solution of the smut problem for Oregon lies in the discovery and development of immune types adapted to commercial production in the different wheat-growing areas of Oregon with their diverse climatic and soil conditions. Several highly resistant sorts have already been found and at least one variety is apparently totally immune to the disease. With these as a basis there is opportunity for the development of desirable wheats by breeding and selection, and hand in hand must go the continued testing for smut resistance to insure perpetuation of this characteristic.

Effects of Seed Treatment on the Physiology of Seed Grain. The object of these studies is to determine the effects of seed treatment on the vital processes of seed grain with a view to overcoming more

effectively any danger to germination and vigor resulting from chemical treatment. It has been determined that formaldehyde will enter the treated seed wheat and that there is an apparent retarding effect on the respiration of the seed varying with the concentration of the solution. Preliminary tests also point to a reduction in respiratory activity in growing seedlings due to previous treatment of the seed with formaldehyde. Further work is under way on the effects of treatment on other vital activities and on the effects of modifications of treatment designed to decrease the extent of injury.

Comparative Studies of Various Methods of Seed Treatment and Types of Seed and Seedling Injury. During the biennium a very extensive series of tests has been carried on with a number of varieties of wheat commonly grown in the State. It was found in the first place that most lots of Oregon seed wheat obtained through ordinary channels bear a very high percentage of injury to the seed coats, especially over the germ, from the usual threshing operations. Injury to stand was found to result not only from ordinary treatment methods but also from the attacks of fungi. The use of the lime-bath following blue-stone treatment was found to reduce very greatly the injury from the use of blue-stone solution alone. The tests indicate that the usual formaldehyde treatment is best employed when the soil and temperature conditions are favorable for prompt and vigorous germination. The practical information secured has guided the Experiment Station in issuing revised instructions for seed treatment.

Stripe Rust of Cereals and Grasses. This disease, known to be destructive in Europe, has been found only in the western part of the United States. While thus far its attacks have not resulted in serious economic losses, these investigations were begun in an effort to learn more about the fungus, its native and cultivated host plants, its distribution and its biological forms. Some 300 varieties of wheat, as well as other cereals, have been tested for susceptibility to the disease. It is expected that the results of these studies will be presented in technical form in a Government publication.

Stem Rust of Cereals. This investigation, now discontinued, was undertaken by the Government to study the distribution of the black-stem rust in the Northwest, the extent to which native and introduced barberries and related plants might be a factor in carrying the different biological forms of the rust, the relation of different varieties of grains and grasses to these rust forms, and the relation of climatic conditions to the disease and its perpetuation. A test garden was established at Corvallis and at Astoria, but the work ceased before results of satisfactory character could be secured.

ONION SMUT CONTROL

This investigation was begun to determine the possibility of controlling onion smut in the onion-set producing sections of the Willamette Valley, where the disease within a short time had caused the abandonment of valuable acreages of beaver-dam soil as far as onion growing was concerned. A careful series of tests was conducted at Hubbard using formaldehyde for seed and soil disinfection, in different strengths

and at different rates of application. It was found that while formaldehyde solution at the rate of one ounce to the gallon of water would result in a high degree of control of smut in the onion-set bed, yet the quantity of solution required is so great as to render the adoption of this method impracticable for onion-set growers with any type of apparatus thus far devised, but the growers of large onions could use the method to good advantage.

TOMATO DISEASES

Western Yellow Blight. Observations covering several years and preliminary investigations during the past two seasons have shown that this disease is a serious and persistent factor limiting the profitable production of tomatoes in many Oregon localities. Tests indicate that it is caused by a soil-inhabiting fungus, a fact which renders the control of the disease a difficult matter. The most promising method of control lies in the development of strains of tomatoes which are resistant to the disease, but preliminary tests have not yet revealed any strain that will resist attack. Much additional work must be done along this line and also to determine other aids for minimizing the damage from the trouble.

Tomato Mosaic. During the past biennium tomato mosaic has been encountered for the first time in the State, causing considerable loss to the crop, particularly in greenhouses. Tests have demonstrated that it also causes damage to tomatoes planted out of doors, and that it is highly infectious under local conditions. The seriousness of the disease would warrant further investigations regarding the methods of transmission and the possibility of control.

PLANT DISEASE SURVEY

As a part of the routine work of the department, records are accumulated annually through correspondence and observations incidental to travel by department members through the State on the prevalence and severity from year to year of the diseases affecting Oregon crops. This information is forwarded to the U. S. Department of Agriculture and becomes a part of the national Plant Disease Survey. The information is of great value as a guide in determining the particular directions in which the services of the department specialists are most needed both for experimental work and for the dissemination of helpful information.

POISONOUS PLANT INVESTIGATIONS

During the biennium surveys have been conducted in both Eastern and Western Oregon and information has been collected regarding the kinds of plants causing the most serious losses of stock, their distribution, the extent of losses, the conditions under which losses usually occur, and the methods in use for preventing losses from poisonous plants. The information has been used in preparing the manuscript for a bulletin on the principal stock-poisoning plants of Oregon.

MISCELLANEOUS INVESTIGATIONS

Some attention has been given to investigations other than those listed above. These studies have often been carried on incidentally in connection with other investigations or have been taken up when time permitted as minor subjects of research. A few are listed here.

Observations on range problems have been continued from a botanical and ecological standpoint including studies on the condition of overgrazing and the plant indicators of depletion and rejuvenation, on the dissemination of range weeds and on the distribution of forage plants in relation to their habitat requirements. A survey was made of the ditchweed situation which was found to constitute a serious problem in practically every irrigation district visited. The species of plants responsible for blocking up the ditches were determined but the problem of control will necessitate intensive study. The possibility of fern eradication, use of embankment-holding plants, availability of native plants as indicators of land values, and other ecological problems received some attention.

The following plant-disease studies have been given some attention: crown gall of fruit trees, disorders of developing fruit due to climatic and soil conditions, the serious nematode (eelworm) disease of strawberry and clover, which should be prevented from further spread in the State, bean mosaic which is widespread, black rot and frog-eye leaf spot of apples, blossom and spur blights, sunflower stem rot, and stump eradication by wood-rotting fungi.

DEPARTMENT OF ENTOMOLOGY

Oregon, with its great variations in altitude, soil, climate, and crops has a corresponding variety of insect problems. As new lines of crop production are established, new pests are continually developing. Old pests appear in new roles and on new hosts, and modifications in established control practices are frequently necessary because of our climatic conditions and their influence on the insect or on the action of the spray.

Horticultural insect pests and the study of spray materials have occupied the major portion of our investigational projects. Investigations in the future should include field-crop insects, such as the alfalfa weevil, grasshoppers, wireworms, and aphids, as affecting the great inland plains area. Forest insects should be given more attention; beekeeping problems peculiar to the Pacific Coast need solution; and the present field of investigation should be developed so as more efficiently to grapple with the problems in insect control yet needing solution.

TOXIC VALUES OF INSECTICIDES AND THE COMPARATIVE RESISTANCE OF INSECTS TO POISON

Work on this project was begun in 1914 and is still in progress. A resume of earlier work with a full discussion of more recent investigations and a summary of the whole are included in Station Bulletin 169, recently published. In addition, seven scientific articles have been published on various phases of the investigations.

An important feature of recent work is the standardization of methods for testing the wetting efficiency of a solution for the surface of a fruit by means of capillary tubes coated with the "wax" extracted from the fruit. Other recent studies have dealt with methods for standardizing the efficiency of the spray material.

In cooperation with the department of Agricultural Chemistry, investigations on the physical properties of (1) the spray material, (2) the spray solution, (3) their improvement, and (4) their relative and

combined effect on the toxic properties and killing power of the material, are well under way.

For discussion of the great amount of work on this project and the important results, the reader is referred to Station Bulletin 169.

INVESTIGATION OF THE ARTIFICIAL PROPAGATION AND DISTRIBUTION OF BENEFICIAL PREDACEOUS AND PARASITIC INSECTS

This investigation was begun in March, 1919, in the hope of finding control measures for serious insect pests, for which adequate control measures had not been developed. A considerable portion of the work thus far has been devoted to general field survey of beneficial insect forms of the State and their host relationships.

Apple Leaf-roller Parasites. Five important parasites of the apple leaf-roller were found present in the Imbler and Hood River fruit districts. These parasites were of considerable importance in preventing excessive outbreaks of leaf-rollers in 1919-20. During the summer months there appears to be a serious shortage of host material on which these parasites may breed. This condition would appear to be a deterrent factor seriously limiting the natural propagation and abundance of the beneficial parasites. It may be possible to render aid by providing host material artificially during the summer period when the natural supply is a limiting factor.

Insect Enemies of Apple-aphids. There are in Western Oregon numerous predaceous enemies of apple-aphids, including three principal species of ladybird beetles, syrphus flies, predaceous mites, *Anthrocoridae*, spiders, etc. There has been a wide fluctuation in the numbers, period of activity, and effectiveness of ladybird beetles from year to year. Continued search in Western Oregon has failed to reveal the small hymenopterous parasites so effective in apple-aphid control in the East, although hymenopterous parasites are found active on aphids attacking low-growing plants such as the cabbage aphis, the grain aphis, the vetch aphis; and one species has been found working on *Aphis sorbi* on plantain.

Observations in connection with evaporation studies indicate that this failure of parasites to attack apple-aphids may be due to climatic factors, especially lack of rainfall during the summer months.

Importation Trials. Through the generous cooperation of the Geneva Experiment Station, N. Y., a number of shipments of natural enemies from eastern states have been received. Though none of the forms have been successfully established to date, a shipment of predaceous forms recently received is now in the introducing cages and promises to become established.

Artificial Feeding Tests. Various combinations of artificial food material have been prepared and fed to ladybird beetles and their larvae. Both adults and larvae fed freely on some of these substances. There was a noticeable difference in the readiness with which different species accepted the food. None of these food materials has proved entirely satisfactory as yet. The problem is partly one of nutrition and of type of cage to employ.

PEACH AND PRUNE ROOT BORER

This project was started in 1916, but reduction in work and changes in personnel during the war period delayed progress. A field station was established at Roseburg in 1919 and acre tests were put on using eighteen different types of washes, sprays, paints, and protectors. Breeding cages were built and life-history studies conducted on a large scale. The studies included three orchards representing different conditions of soil, altitude, and root stocks. Fall treatments of sprays and washes were applied also at Corvallis, Albany, and Salem.

The results of all tests were carefully checked in the spring of 1920, and with the most promising materials twenty-two new tests were started. It is hoped that by the close of the year significant results can be reported from these large-sized tests.

The prune root-borer causes an annual loss in Oregon estimated at about $40,000, but it is expected that the investigations under way will produce methods which will reduce this loss by eighty percent.

LEAF-ROLLERS AND FRUIT-WORMS OF APPLE AND PEAR

Because of the wide distribution and particularly serious injury in Hood River and Imbler, much of this investigation has been done at these points rather than at the central Station.

The species are *Archips argyrospila* and *A. rosaceana*. Both occur at Imbler, Hood River, and to a lesser extent in the Willamette Valley. The latter species is of minor importance.

In 1919 oil sprays applied in April gave 50 to 90 percent control. Unsprayed trees showed 100 percent infestation. Calyx sprays of oil, arsenate, and Black Leaf 40 killed about 33 percent of the young larvae. In 1920 heavy oils gave better kill than light oils; late applications gave better kill than early, the nearer the hatching period the better. Earlier applications, in order to be equally effective, require higher concentration of spray, weaker dilution being applied near hatching time. The value of application is affected adversely by rainy weather.

TREE CRICKETS OF OREGON

This project is a rather minor one and not a great deal more has been attempted than to accumulate data as occasion permits. The pest is serious on cane fruits, the process of oviposition weakening the canes. One species oviposits in the bark of prune and apple and is apparently an active agent in disseminating a species of bark canker.

Five species of tree crickets have been collected. Four have been studied as to life-history and habits. The Western forms vary somewhat both in appearance and habits from the allied Eastern forms. Preliminary studies indicate that it is one species which oviposits both in cane fruits and in the bark of prune and apple. The forms are two distinct varieties, however, so far as habits are concerned.

THE GARDEN SLUG

Investigations on this project were concluded during the biennium, and the results published as Station Bulletin 170.

INVESTIGATION OF APHIDS INJURIOUS TO APPLES

The injury from aphids is general, and where unchecked is serious. This investigation on the aphids injurious to apples was begun in 1917 in the hope of improving upon control methods already recommended by the Station. The investigations include studies of life-history, habits, control, the ecological factors involved, and their effect.

Fall sprays for the egg-laying female aphids proved effective in checking aphis outbreaks. Under control conditions *Aphis sorbi* was reared experimentally on apple throughout the summer. There was no indication of the production of true sexed forms in the fall, however, and all the specimens were killed by the severe winter. *Aphis sorbi* was again found to pass the winter on plantain in the field. In protected areas these forms were little affected by the severe winter. The species has been found infesting wild crab *(Malus rivularis)*, causing the typical curling of the foliage and malformation of the fruit. Elaborate studies with *Aphis pomi* on the exact relationship between aphid activity and environmental factors are yielding a great deal of interesting data.

FOREST INSECT INVESTIGATIONS

Preliminary work on this project is under way. Station Bulletin 172 has been published giving compiled data and original investigations for the yellow pine bark-beetle. Additional investigations are planned, but the work will be limited, due to lack of funds.

MINOR PROJECTS

The Pear-thrips appeared in Oregon in destructive numbers for the first time in 1919 in the prune section near Salem. The serious injury last year covered about 300 acres and resulted in a total crop loss.

Surveys of the distribution of the pest have been made. Spray tests and field observations on the thrip were undertaken at Salem in 1920. Decidedly adverse climatic conditions during the period of thrips activity, however, rendered the spray tests of no value.

The seasonal activities of the pest, climatic factors in control, surveys for distribution, and control measures should be undertaken before the pest becomes widespread.

Codling-moth. Life-history records, emergence dates, and general information on spray dates have been continued as an aid in directing timely spraying.

Grasshoppers. Tests of substitutes for bran in mixing poison bait and effect of time of day in distributing poison have been further investigated. Use of cheaper materials in the grasshopper campaign in Fox Valley, Grant county, resulted in the saving of hundreds of dollars.

Filbert Bud Mite. Spray tests for control put on at Sheridan.

Cerambycid Borer in Gooseberry. This is apparently a new pest causing serious injury to commercial gooseberry plantings in the Salem district. Breeding-cage material has been collected to rear adults.

Miscellaneous Breeding-cage Experiments. Rearing material sent in includes maggot from potato; cutworms from strawberry, hops, onions, and orchard; army worms; borers from prune and cherry.

BRANCH EXPERIMENT STATIONS

The branch stations at Astoria, Burns, Hermiston, Hood River, Moro, Talent, and Union were established and are maintained to study major agricultural problems of the seven rather distinctive agricultural sections in which they are located. In addition they supplement the investigational work of the home Station at Corvallis by testing for application in their respective localities, results obtained from investigations on special subjects at the home Station. The Federal Department of Agriculture continued to cooperate in the irrigation investigations at the Hermiston station, in the cereal investigations at the Moro and Burns stations, and in forage-crop investigations at the Moro station.

The character and extent of the work and some of the results at each branch station are given briefly in the following pages.

JOHN JACOB ASTOR BRANCH STATION, ASTORIA

The John Jacob Astor station consists of approximately forty acres of tide land and about fifteen acres of logged-off hill land. The investigations of first importance have been in dairying, forage and farm crops, soil fertility, and reclamation of swamp land.

Dairy Investigations. A dairy herd was established at the station in 1914 and is maintained for experimental feeding and general problems of herd improvement and herd management under Coast conditions. From a mixed herd of Jerseys and Guernseys of rather poor production qualities, to start with, the herd is gradually being improved in production qualities and developed toward a pure-bred Guernsey herd. There are now in the herd seven pure-bred Guernsey cows, six grade Guernsey cows, and three grade Jersey cows over two years of age.

The herd management is on a basis of economy of production rather than maximum production. All milkings are weighed and recorded, and an accurate record is kept of all feed used. These data are the basis for culling unprofitable cows from the herd and for a study of comparative production from different feeds and feeding systems.

The effect of summer soiling on milk production has been made a special study during the past three years. Normally on pasture without soiling the summer production drops nearly 50 percent. The three years' results show that this drop can be reduced 15 to 20 percent by summer soiling. The actual cash return from the summer soiling depends upon the price of dairy products, average production of the herd, amount of labor required to produce the soiling crop, and the crop grown. Several dairymen have adopted a system of soiling similar to that followed at the station and without exception are finding it profitable. This investigation is being continued and in addition, trials are under way to determine the relative effects on production of feeding a narrow and a broad nutritive grain ration with pasture.

Forage Crops. Forage crop investigations have included: (1) an experiment consisting of eleven plots to work out a soiling-crop system having the most satisfactory dates of planting and maturity and yield

per acre; (2) tests of individual species to determine their suitability for soiling crops; (3) comparative tests of individual species and combinations for silage.

As a result of the work on forage crops a system of soiling crops has been worked out, which makes possible the use of this system to feed the whole year without the use of a silo. The silo, however, can be used advantageously in early spring and during the winter months.

Rye and vetch sown September 1 can be used for soiling purposes April 20 or earlier, depending on the spring. Grey winter oats and common vetch sown in succession from September 1 to January 1 will furnish a palatable soiling crop from May 5 to July 25. This crop can be planted any time from September to January when the soil can be worked. Plantings made on January 5 of 1920 were cut on July 19.

Peas and oats are the most palatable of all of the soiling crops grown. February plantings of this crop can be used for soiling by July 1. Plantings every fifteen days will give feed until August 15. Even though the crop passes the most desirable stage for soiling, as it matures it is still relished by the cows. The yield per acre decreases at the rate of about two tons per acre for every 30 days the planting is delayed after March 1.

After the peas and oats have been fed either Pomerain white globe turnips or one of the millets can be used. They should be planted the first week in May. This is the weakest point in the system especially if there is no bottom land on which to grow crops at this season. The millets make the best feed in September.

The cow-horn turnip is an excellent crop for feeding from September 15 to October 15, after which it deteriorates very rapidly. From October 15 until the spring crops come on, rutabagas may be fed.

In growing crops for a soiling-crop system the seeding should be 25 percent heavier than for ordinary field crops of the same varieties. A liberal application of manure and special care in the preparation of the seed bed are also important. The heavier the crop the less will be the cost of handling.

Japanese barnyard millet has proved the most satisfactory late soiling crop. It reaches the proper stage for soiling after September 10 and can be used until the first frost. It is eaten readily by dairy cows and ranks with peas and oats as a desirable soiling crop. It requires a well-fertilized soil for satisfactory growth. In 1918 a yield of 16.7 tons per acre of green feed was secured.

Sunflowers, horse beans, sunflowers and pole beans, and peas and oats were grown and tried for silage. The peas and oats have thus far proved most satisfactory. As a result a number of dairy farmers have planted peas and oats this year for the first time. The introduction of these crops is of great value to the dairy interests.

Tests of Commercial Fertilizers With and Without Manure. This investigation was started in 1918. Eleven plots of hill land are used in a four-year rotation, with peas and oats one year, timothy and clover two years, followed by a cultivated crop, potatoes, one year. The fertilizers are put on and timothy and clover seeded with the peas and oats. One half of each plot received manure at the rate of 15 tons per acre. The experiment has not run long enough to warrant conclusions.

The manured acres, however, produced much heavier than the unmanured; and both lime and super-phosphate appear to be beneficial.

The use of super-phosphate on ground grown to root crops has for three years shown an increase in the crop. Trials by 30 farmers in 1919 with two exceptions showed striking results. The addition of superphosphate in growing root crops seems warranted as a common practice.

Land Clearing and Drainage. The clearing and drainage of land has been a big problem at the station. With the special fund of $2000 made available by the legislature in 1919, 1400 feet of main ditches have been dug and 300 feet laid and covered; 1820 feet of laterals have been dug and 1670 feet laid and covered; 1600 feet of sloughs and shallow ditches drained by the tiling have been filled and are now in crops. The wire grass and sedges have been cut on 24 acres and all tide land not yet cleared has been slashed, burned, and sown to grass. All stumps above ground have been piled and burned and stumps and logs near the surface of the ground have been removed from five acres. This work has improved the land greatly and gives larger fields much needed for the experimental work.

The drainage experimental field is now complete and valuable data can be secured. Drains laid previous to 1919 are giving very good service.

HARNEY COUNTY BRANCH STATION, BURNS

The Harney County branch station was established in 1911 to investigate agricultural problems on dry, arid, or non-irrigated lands in Harney county and other similar areas. Seven years of experimental tests have been completed at the station in dry-farming investigations. In 1917 a small pumping plant was installed and preliminary experiments were started in growing various crops under irrigation. The irrigation investigations have been extended until twenty-three acres were in use for irrigation experiments during the season of 1920.

The investigations in dry-land agriculture have included varietal trials, rate and date of sowing field crops experiments, tillage experiments, crop-rotation experiments, and minor investigations in testing bush fruits and ornamental trees. Similar experiments are now under way under irrigation, and in addition, duty of water trials, methods of irrigation studies, and fertilizer experiments have been started.

Varietal Trials. The varietal trials both under dry-land farming and under irrigation have been with wheat, oats, barley, rye, field peas, corn, alfalfa, sunflowers, grasses, potatoes, and other minor crops. The major work has been with cereals and alfalfa. Wheat being the most important crop of the section major attention has been devoted to experiments with this crop. With the development of the experimental work in irrigation farming, more attention is being paid to forage and hay crops.

In a seven-year comparative test without irrigation spring wheat, Early Baart, with an average yield of 15.7 bushels, has out-yielded the best winter wheat, Turkey Red, by an average of 3.5 bushels per acre. Little Club out-yielded all other spring wheats on dry land in 1919, producing 8.8 bushels per acre. Winter wheat failed entirely on dry land in 1919. Under irrigation Early Baart gave the best yield in 1919 and for a three-year average with a yield of 15.5 bushels per acre.

Spring rye has proved more dependable than winter rye both on dry land and under irrigation. It has not yielded as well as spring wheat but is better for hay. Winter rye failed on dry land and under irrigation produced 12.6 bushels per acre in 1919, while spring rye produced 16.6 bushels on dry land and 18.2 bushels under irrigation.

Sixty-day oats has produced the best eight-year average yield, 20.7 bushels per acre on dry land. Rustless selection oats has given the best three-year average yield, 32.7 bushels, under irrigation. Hannchen barley, C. I. No. 531, leads in a seven-year average on dry land with an average yield of 19.1 bushels per acre, and for three years under irrigation with an average of 35.6 bushels per acre.

Baltic alfalfa has been the best producer on dry land and under irrigation, both for seed and for hay production. Grimm is a close second with Turkestan third. The six-year average for Baltic in rows on dry land is 1.1 tons per acre; the three-year average under irrigation is 4.4 tons per acre.

Good stands of red and alsike clover were secured for the first time in 1919 under irrigation.

Bliss Red Triumph potatoes led in a five-year average on dry land with 53.7 bushels per acre and a yield of 123.3 bushels per acre in 1919. Under irrigation Extra Early Rose has averaged 110.9 bushels per acre for three years and made 124.2 bushels in 1919. Half-sugar mangels yielded from 5 to 10 tons per acre under irrigation in 1919.

Date and Rate of Seeding. About April 10 has been found best for seeding spring wheat without irrigation; about May 1 to 10 for spring barley; April 15 or a little later for spring oats and April 15 to 25 for spring rye. About 30 pounds of good spring wheat per acre is recommended for seeding on dry land on a well-prepared seed bed; for spring barley 40 to 48 pounds on a well-prepared seed bed; for oats one bushel; and for spring rye one bushel.

Tillage Experiments. The tillage experiments were not productive either in 1918 or 1919, due to drought, frost, and pests. Results since the station was established indicate that in growing wheat after summer fallow it is important (1) to work the land as early as possible, (2) to harrow early-plowed land immediately after plowing; (3) to keep the fallow clean of weeds; (4) to plow stubble early in the spring. It is believed that further investigations in methods of tillage are of extreme importance in eventually developing satisfactory farm practice for dry-land farming under conditions similar to those at the station.

Rotation Experiments. Drought and frost interfered with the rotation experiments to some extent by reducing yields in 1918 and in 1919. The results, however, as in previous years, are in favor of the spring wheat-fallow rotation for the dry-land farming. The irrigation rotations have not run long enough to give data. Good returns were secured from all plots except timothy and clover.

Fertilizer Experiments. Fertilizer experiments were started in 1919. At least one more cropping season will be necessary to give data of value and a number of years for conclusions.

Duty of Water. Duty-of-water experiments are under way, but results to date have been uncertain because the land under irrigation

has been lacking in uniformity and not properly leveled. These conditions are being remedied as rapidly as funds will permit so that reliable data can be secured in the future.

UMATILLA BRANCH STATION, HERMISTON

The work of the Umatilla Branch Experiment Station is carried on in cooperation with the office of Western Irrigation Agriculture Investigations of the U. S. Department of Agriculture. When the station was established, interest in horticulture on the Umatilla Reclamation Project was keen and naturally the experimental work had largely to do with certain phases of horticulture. As the project developed it was found that the trees made rather an indifferent growth and that the locality was subject to severe spring frosts. Recent interest, therefore, has been almost entirely in general agriculture with alfalfa as the principal crop, and the work of the station has been changed by putting more stress on the irrigation, soil fertility, and crops problems and less on problems of horticulture. As fast as the horticultural experiments have been completed the trees have been removed and the land used for other experiments.

The principal projects that are being worked on at the present time are: soil-fertility experiments; crop-rotation experiments; irrigation experiments; lysimeter investigations; and testing of crop varieties.

Fertility and Rotation Experiments. The soil-fertility and rotation experiments are closely related on the station soil type. The commercial fertilizer rotation, and the manured rotation are used to ascertain results along both lines. The yield of alfalfa without manure for five years has averaged 3.83 tons; with 8 tons of manure per acre, 5.16 tons; and with 32 tons of manure, 6.12 tons of alfalfa hay per acre. The increased yield per ton of manure was much larger when the manure was applied at the rate of 8 tons than when applied at the rate of 32 tons. Valuing hay at $15 per ton the 8-ton application of manure was valued at $2.49 per ton by reason of the increased yield; when applied at the rate of 32 tons the value was only $1.07 per ton. The increased returns per ton of manure are not so pronounced on the corn in the rotation.

One of the most pronounced results from manure was secured during 1919 on the irrigation experiment in field A3. This piece of land had been heavily graded when first put under cultivation and had blown and washed considerably while in row crops. The alfalfa had given poor results; manure was therefore applied at the rate of 8 tons per acre during the winter of 1918-19. The average yield in the experiment was 2.44 tons per acre in 1918. The yield in 1919 was 3.78 tons, an increase of 1.34 tons or 54.9 percent.

Irrigation Experiments. The irrigation experiments consist of duty of water trials both with varying intervals and varying depths of applications, and experiments to ascertain the best width and length of borders on this soil type. Alfalfa irrigated once in two weeks did not produce as much hay as when irrigated each week but the net return was greater on account of the lower cost of production. The plot irrigated once in three weeks gave the highest duty of water per acre-foot but the yield per acre was too low to secure the best returns from the

land. The soil-moisture studies show that the soil is capable of holding an application of approximately an acre-inch of water per acre-foot of soil so the depth of application in the experiments has been limited to 4 acre-inches to wet the 4 acre-feet, which is the root zone of the alfalfa. Time and amounts of water delivered to the farmers are based largely on these experiments.

The size-of-border experiments show that water can be run 175 feet as economically as it can 100 feet, but when run 250 feet 50 percent more water is required. On borders 200 feet long it has been found that borders 20, 25, and 30 feet wide are equally economical of water, but borders 35 and 40 feet wide require considerably more water than can be stored in the soil and deep percolation loss results.

Lysimeter Investigations. It was found from the soil-moisture results of the irrigation experiments that the loss of water from deep percolation was one of the chief problems in the handling of water. In 1915 a set of eight lysimeters was installed to study this loss more closely. The table below gives the average results for the different soils and crops for five years.

Lysimeter number	Soil	Crop	Application	Percolation	Percent
			in.	in.	
1	medium sand	no crop	57.96	39.64	68.5
2	medium sand	soy beans, vetch	58.36	27.70	47.6
3	medium sand	alfalfa	57.96	19.94	22.3
4	medium sand	alfalfa manured	57.96	10.83	18.7
5	fine sand	alfalfa	60.03	6.72	11.2
6	coarse sand	alfalfa	60.03	14.92	25.0
7	silt	alfalfa	59.69	None	.....
8	silt loam	alfalfa	61.03	None	.....

During the past two years there has been a slight tendency of the soil to hold more moisture than it did originally.

Crop and Variety Tests. The crop and variety testing work has been with silage crops, alfalfa, pasture grasses, ornamental plantings, windbreak trees, and fruit trees.

During the past two years, 51 varieties of corn and 1 variety of sunflowers have been tested. Mammoth Russian sunflowers yielded 28.3 tons, which was a far larger yield than from any variety of corn. The highest yielding corn both years was Hopi, a Southwestern Indian variety, which produced 10.8 tons and 8.93 tons of ensilage for the two years. Bloody Butcher, Dependable Yellow Dent, and Sullivan White Dent, a local strain, have been the most consistent yielders, next to Hopi. The frost-free period on the Umatilla Project is long, and any of the long-season eastern varieties can be grown to maturity.

A test of 12 strains and varieties of alfalfa was planted in the spring of 1920. In the past only common alfalfa has been grown on the project but since the seed industry has grown to considerable proportions a preliminary test was made in 1918 with the idea of introducing some of the higher-priced seed varieties. The results so far give some evidence that Baltic will be a higher yielder than the other varieties, which all yielded practically equal.

Orchard grass, smooth brome grass, meadow fescue, and blue-grass have been the best varieties of pasture grasses tried. Alsike clover ap-

pears to be better suited to local conditions than white clover but they are both short lived. It is not thought that grass pastures will be practical except on seepage ground until more frequent irrigation water can be secured.

The test of ornamental shrubs and trees consists of a quarter acre planting of some sixty species to ascertain which species are valuable for yard plantings and for windbreaks. Black locust has been found to be the best windbreak tree but Western yellow pine has made a good growth and is being recommended for windbreaks around farm buildings as it gives protection throughout the year, while the locust is of little value during the winter and windy season.

Miscellaneous. The station cooperates closely with the county agents in Umatilla and Morrow counties in which the Irrigation Project is located and with the Federal Demonstration Agent on the Project. Frequent meetings are held with the county agents and assistance is given in planning and carrying out demonstrations.

The local conditions are similar also to those on several projects on the upper Columbia River and the results of the station are proving of value to the settlers on these lands. During the past spring seven meetings were held in Benton, Franklin, and Walla Walla counties in Washington at the request of the county agents. Between 500 and 600 people attended these meetings and as a result the border method of irrigation which has been the means of bringing the Umatilla Project under cultivation is now firmly established in the upper Columbia Basin.

HOOD RIVER BRANCH EXPERIMENT STATION

Investigational Work

The Hood River Branch Experiment Station is maintained by the State of Oregon in cooperation with Hood River county. The work of the station is investigational only in part, a great deal of time being spent in assisting orchardists of the Valley through extension work. The investigations are carried on in cooperation with private individuals as the station has no land. The major problems are those dealing with the study and control of orchard pests and diseases and horticultural questions.

Scab Spraying Investigations. Effective control of scab is a matter of first importance to the orchard industry. The investigations on this subject have been continued and include: (1) the testing of proprietary sprays on the market; (2) determining the strength of dilutions necessary to effect control; (3) studies of spraying practices as a basis for a spraying program which will give the orchardists complete control of the disease. The important feature of this work is to limit the number of present-used sprays as much as possible and to develop the most effective and most economical spraying practice. The studies have been under way for a number of years and each year valuable new information as to strength of sprays necessary and their application has been developed and put in practical use in the Hood River Valley.

Codling-moth Studies. The life-history of the codling-moth under Hood River Valley conditions has been studied each year during the past

six years, and based upon these studies a spraying program has been arranged for each year. It has been found that more than a month of variation in spraying dates from one season to another has been necessary for most effective control. This work demonstrates clearly the importance of studying the life-history of the codling-moth in each apple-growing section each year if entirely effective control is to be obtained. Control measures with reference to the different methods of application are fully discussed in Station Bulletin 171 just issued.

Comparative Tests in the Use of Present-day Spraying Equipment. The investigations under this project are largely finished. The data secured to date are included in Station Bulletin 171, "Spray Gun Versus Rod and Dust in Apple Orchard Pest Control," just issued.

Root Rot Investigation. The purpose of this investigation is to find if possible a means of reducing the losses that are resulting from root-rot disease. After the disease has become established in the root system control appears impracticable. The most promising means of reducing the losses seems to be through a study of root stocks to find if there are stocks of apple, cherry, and pear which are more resistant to the disease than others and suitable for propagation purposes. The problem is a difficult one and will require a great deal of time to reach definite conclusions. Work at the branch station thus far is preliminary and is being done in cooperation with the department of Botany and Plant Pathology of the home Station at Corvallis.

Leaf-roller Investigation. This study has been carried as a minor project during the past five years, to secure further information relative to control and habits of the leaf-roller. A good deal of valuable information has been secured and put in practical application through direct recommendations to orchardists. Eight different combination tests for control were used in the spring of 1920. Results from these tests are not yet available.

Pear-Spraying Experiment. Close observations show that certain pear varieties suffer from applications of spray that are now recommended for the control of scab. For the past three years the problem of determining a safe application for the De Anjou variety has been under study. It is believed that a safe and at the same time, effective, means of spraying this variety has been worked out. These data will be published as soon as results of the present season are available. Information needed relative to the control of the pear-leaf blister mite will be included.

Winter Injury. Minor observations are under way to determine the best procedure in handling trees injured by severe winter conditions in 1919-20.

Fertilizers for Orchards. From 1914 to 1918 much experimental work with fertilizers was conducted in older orchards. The results are summarized in Station Bulletin 166, 1920. A number of additional tests were started in 1918 to 1920 to determine the best fertilizer for apples, pears, strawberries, potatoes, and clover on different soil types of Hood River Valley.

The outstanding feature of the results from the fertilizer investigations is that nitrogen has been the limiting factor under Hood River Valley conditions. Commercially nitrogen has been supplied by small

annual early spring applications of nitrate of soda at the rate of three pounds per tree. Of late years where leguminous cover crops, such as clover or alfalfa, are grown in the orchard, the response from the nitrate of soda applications has been less striking than when the experiments were started. This would naturally be expected since it is estimated that from 75 to 150 pounds per acre of nitrogen may be added annually by the legumes. This is the equivalent of that added by 939 pounds of nitrate of soda testing 16 percent nitrogen, or, figuring 70 trees to the acre, 13.3 pounds per tree, an amount three or four times that annually applied in the commercial form. It is hoped that the use of commercial nitrogen may be dispensed with altogether.

The best methods of maintaining a stand of alfalfa in the orchard should be further studied. This is difficult since the natural grasses tend to crowd out the legume and make it less efficient for the purpose planted. The relation of mixed fertilizers to yield and keeping quality of fruit should be studied also. Potash and phosphoric acid combined with nitrogen in commercial form is being tried with these points in mind. Experiments in California with nitrate of soda indicate that this fertilizer can readily be used to excess. Both the trees and the physical and chemical condition of the soil have been injured.

Shade Crop Studies. During the summer of 1919, studies were started to determine the influence on tree growth of different methods of handling alfalfa in orchards. Two cuttings of hay removed; two cuttings of hay, one allowed to lie; two cuttings, both allowed to lie; and no cutting at all, are under comparison. Sulfur was applied as a fertilizer in the spring of 1920. The result of these studies will be of considerable importance, but conclusions cannot be looked for inside of a number of years.

Pruning Experiments. Observations as to the most effective pruning practices are continuous. In 1918 a specific experiment was started to compare annual winter or summer pruning with winter or summer pruning every two years. This experiment has been conducted with sixteen-year-old Newtowns. Winter injury has interfered with the experiment to a considerable extent.

Variety Tests. Variety tests are in progress with strawberries and potatoes, both of which are important crops in the Hood River Valley. Forty-four varieties of strawberries are being tested in one block to find if possible some variety more profitable under local conditions than the Clark. No variety has been found which appears suitable as a substitute for the Clark. This investigation will be continued if varieties of promise can be secured.

Eight varieties of potatoes are under test for yields on different soils. These experiments have not been under way long enough to give any definite information.

Apple Orchard Survey. This is one of the major projects in the horticultural investigations of the station. A great deal of information has been secured which will be thoroughly analyzed and reported for publication during the coming winter.

Time of Picking Fruit. Preliminary work in determining the best time to pick Spitzenbergs and Anjous has recently been started as a cooperative test by Mr. Childs and Mr. Brown. This work will include a

study of all factors of importance such as the character of the fruit, keeping quality under storage conditions, ease of picking, windfalls, and net increase in tonnage as a result of late picking.

Extension Work

Investigations at the Hood River station are essentially studies in orchard practices. For this reason and because Hood River county has no agricultural agent or extension specialists, members of the branch station staff devote a great deal of time to extension and demonstration work. Growers are visited in their orchards and such suggestions are given as seem advisable. This assistance is greatly appreciated by orchardists and also keeps the staff of the station informed as to the character of investigations which will be of the most help to the agriculture of the Hood River Valley.

SHERMAN COUNTY DRY-FARM BRANCH STATION, MORO

The work on the Sherman County branch station is carried on in cooperation with the Offices of Cereal and Forage Crop Investigations of the United States Department of Agriculture. The following lines of investigation are in progress:

(1) Varietal trials with field crops.
(2) Rate and date of sowing experiments with field crops.
(3) Cereal breeding investigations.
(4) Tillage experiments.
(5) Soil moisture and nitrate investigations.
(6) Crop rotation experiments.
(7) Cereal disease investigations.

Varietal Trials. Extensive varietal trials have been conducted during the past eight years with wheat, barley, oats, field peas, corn, and potatoes. The major portion of the work, however, has been with the cereals, wheat, oats, and barley. Wheat being the most important crop grown in Eastern Oregon, the work with this cereal has been emphasized.

All the commercial wheat varieties of the United States, as well as those of Australia and India have been tried in nursery rows, and those showing any promise have been increased and tested in larger plots. Strains and varieties of winter wheat have been found that are superior to locally grown varieties and these have been increased and distributed to farmers. A large part of the Turkey wheat now grown in Sherman and adjacent counties is from seed originally obtained from the branch station. As a result of this work Sherman county has now become the most important producing center of Turkey wheat in the Northwest.

A spring wheat recently produced by the plant breeders of Australia has, in a three-year trial at the branch station, exceeded the yield of commonly grown spring wheats more than 30 percent. Seed of this desirable variety, Hard Federation, has been increased on the branch station so that about 250 bushels will be available for distribution to farmers for sowing in the spring of 1921. Baking and milling investigations with Hard Federation wheat have shown it to be superior to Early Baart and Pacific Bluestem for bread making.

Of the many barley varieties that have been tried, Mariout and Meloy beardless have proved to be the highest yielders. The highest yielding oat varieties have been Sixty Day and No. 357. O'Rourke, Carleton, and Bangalia field peas are recommended as the best field pea varieties. Minnesota 13 and Walla Walla White Dent corn have proved to be the best adapted corn varieties.

The varietal testing work will likely continue to be a necessary part of the station's work, as new varieties are continually being produced and it is important that farmers be furnished with accurate and reliable information as to their value.

Rate and Date of Sowing Experiments with Field Crops. Rather extensive rate and date of sowing experiments with wheat have been conducted. It has been found that early to medium-early sowing of winter wheat (September 15 to October 1) will ordinarily result in higher yields of winter wheat than later sowing, especially during seasons when moisture conditions are such as to insure germination and emergence of the wheat within a reasonable time after sowing. When autumn rains do not come early enough to insure germination there appears to be no advantage in sowing winter wheat before October 1.

With favorable moisture conditions, 40 to 50 pounds of seed of winter wheat per acre have been sufficient for maximum yields. Thicker sowings (70 to 90 pounds) are recommended when wheat is sown later than October 15.

For spring wheat, the highest yields have always been obtained from the earliest sowings. The correct rates of sowing have also been determined for the standard spring wheat varieties grown on the dry lands of the Columbia Basin.

Cereal-Breeding Investigations. In addition to determining the best grain varieties for the dry lands of the Columbia Basin, considerable time during the past four years has been devoted to trying to produce new, improved wheat varieties. This has been done by pure-line selection and by hybridization. The purposes of the investigations have been mainly to secure an earlier-maturing high-yielding, beardless winter wheat with the kernel type and good milling qualities of Turkey; and to produce an early-maturing, high-yielding spring wheat of good milling quality. Hundreds of hybrids and selections have been made and are now under observation. The nature of this work is such that it will require considerable time before it can be definitely determined whether any of the hybrids and selections already made will be more valuable than present commercial varieties.

Tillage Experiments. Extensive experiments to determine the most profitable tillage methods for wheat production under the summer-fallow system have been carried on for the past eight years. Data of much value to farmers of this section have been already obtained. These experiments have included different methods and time-of-plowing tests and different methods of handling the summer fallow for wheat production. The following figures show the yields of Turkey wheat obtained after summer fallow plowed on different dates. The figures represent

average yields of eight one-tenth acre plots each year for the period 1913 to 1919 inclusive.

Yields of winter wheat after fallow:

		Bushels per acre
(1)	Plowed April 1	28.7
(2)	Plowed May 1	26.2
(3)	Plowed early in fall (dry) with moldboard plow	26.1
(4)	Plowed early in fall (dry) with disk plow	23.2
(5)	Plowed late in fall (wet) with moldboard plow	22.5
(6)	Plowed late in fall (wet) with disk plow	22.3
(7)	Plowed June 1	22.2

These figures emphasize the great importance to the farmer of the proper time and method of plowing the ground to get maximum yields. This information has already been responsible for an annual increase of thousands of bushels of wheat in the Columbia Basin region and further increased production will result when more of the farmers can arrange their farming operations so as to plow their ground earlier in the spring.

Eight years experimenting with various methods of cultivating the summer fallow after plowing justifies the following conclusions:

1. Permitting weeds to grow on the summer fallow not only reduces wheat yields but also injures the milling quality of the wheat.
2. Subsurface or surface packing of ground to be left fallow does not ordinarily increase wheat yields.
3. After a mulch has been established, further cultivation of the summer fallow for any other purpose than to kill weeds is unnecessary.
4. The cultivation of ground plowed late in the spring when the ground is dry is of no value. It does not aid in conserving moisture or in increasing wheat yields.
5. Harrowing winter wheat in the spring will usually reduce wheat yields.

Soil Moisture and Nitrate Investigations. In cooperation with the departments of Soils and Agricultural Chemistry, of the home Station at Corvallis, soil moisture and nitrate investigations were started in the spring of 1919. These studies are for the purpose of determining the effect of different tillage methods on the moisture and nitrate content of the soil and to ascertain what relation these have to the yield and quality of the wheat crop. Experiments are also being conducted to determine the water requirements of crops when grown in the field and when grown in large pots under controlled moisture conditions. Some interesting and valuable information has already been obtained on these subjects, but it will be necessary to continue this work for two or three years longer before definite conclusions can be reached on the many complex problems involved.

Crop Rotation Experiments. Fourteen crop rotation systems which were started in 1912 have been continued since that time without interruption. Fifteen additional rotations have been started since 1912. Accurate data have been kept on the yields of the various crops in these rotations. The following crop rotation schemes, in the order named, have proved the most profitable of those that have been in progress six years or more, based on 1919 prices of farm crops and cost of producing them:

(1) Spring wheat—barley—potatoes.
(2) Field peas continuously.
(3) Spring wheat—corn—spring barley.
(4) Winter wheat—summer fallow.
(5) Spring wheat—barley—corn.

Wheat and barley are at present the only crops grown to any extent on the non-irrigated lands of the Columbia Basin. The fact that the branch station has found that other crops can be profitably grown in a rotation with grains, is of much significance. It will no doubt answer the question as to how these lands can be made permanently productive, as may prove impossible under the present one-crop system of farming.

An additional series of permanent fertility experiments have been planned, involving the use of commercial fertilizers, barnyard manure, and straw. Little has been done, however, due to lack of funds. Commercial fertilizers may not prove profitable for the present type of grain farming in the Columbia Basin, but it is of considerable importance to ascertain what influence, if any, commercial fertilizers, barnyard manure, straw, etc., will have on the yield and quality of the wheat crop in certain rotations.

Cereal Disease Investigations. Extensive experiments have been in progress during the past three years in methods of controlling stinking smut, or bunt, in wheat and of testing wheat varieties for resistance to bunt. In 1919 all of the commercial wheat varieties of the United States, Australia, and India, as well as of a large number of pure-line selections from Crimean wheats, were tested for their resistance to bunt. Of these comparatively few showed any marked resistance to this destructive disease. A few varieties, however, were discovered which appear to be immune. These, together with several other highly resistant pure lines, will be increased as rapidly as possible and tested for yield. Hybrids will also be made between these apparently immune and highly resistant varieties and the present high-yielding varieties in order to get both the smut-resistance and high-yielding qualities combined in one variety.

The cost of seed treatment and loss of seed through injury to germination, amount to more than $100,000 annually in the Columbia Basin of Oregon. An additional greater loss is caused by failure to get thick enough stands of winter wheat because of seed injury through treatment for smut, resulting in many cases in reduced yields and frequently in the necessity of reseeding. The production of a satisfactory wheat sufficiently resistant to bunt so that seed treatment will not be necessary, would mean an immense saving to the farmers of this section.

SOUTHERN OREGON BRANCH STATION, TALENT

The work of the Southern Oregon branch station is centered almost entirely on horticultural problems of this important fruit-growing section of the State. Many of the results, however, are of much wider importance and application. The major investigations of the station are discussed briefly below.

Soil Analyses. During the year 1911 the United States Bureau of Soils made a complete soil survey of the soils of Jackson county, Oregon, in which all the tillable soils were classified and mapped. The branch station in cooperation with the Agricultural Chemistry department of the home Station collected typical composite samples of all of

these soil types, including surface and subsoils, and made exhaustive chemical analyses of these during the years 1915 to 1918. The results of this work were completed and published January, 1920, in Station Bulletin 164. This information will be of special value in ascertaining the cause of unsatisfactory yields, in planning rotation and cropping systems, in making fertilizer recommendations, and in planning fertilizer and other experiments. The analyses show that all of the soils of Jackson county are well supplied with potassium, calcium, and magnesium. The nitrogen, phosphorus, and sulfur content varies considerably on the different soil types, some soils containing sufficient of these elements for maximum production while others are notably deficient. The elements nitrogen and sulfur are notably low on many of the soils, and must be increased before maximum crops can be produced.

Sulfur as a Fertilizer for Alfalfa. Work on sulfur as a fertilizer for alfalfa developed out of a preliminary general fertilizer experiment on alfalfa conducted during the years 1912 and 1913. It was taken up specifically with reference to sulfur in the spring of 1914. From that time until the close of 1919 extensive experiments were conducted to determine the value and importance of sulfur in the growing of legumes in Southern Oregon. The results obtained have proved beyond all question the great importance of sulfur as a fertilizer for legumes in Southern Oregon. It was found that alfalfa requires much larger quantities of sulfur for maximum growth than the earlier analyses indicated, that many of the soils of Southern Oregon are deficient in this element, that this deficiency can be easily and cheaply remedied by an application of various materials containing sulfur, and that the use of sulfur fertilizers is profitable. For example, on many of the adobe soils on which it was formerly impossible to grow alfalfa, abundant crops are now grown after an application of 100 pounds of sulfur every second year. Applications of the following fertilizers, containing sulfur, had a similar beneficial effect on the growth of alfalfa: flowers of sulfur, gypsum, superphosphate, sulfate of potash, sulfate of ammonia, magnesium sulfate, iron sulfate, and sodium sulfate. On these same soils applications of phosphorus, potassium, nitrogen, and lime, without sulfur had little or no effect on the growth of the alfalfa. The results obtained during the season of 1919 are identical with those obtained during 1914 to 1918. Results for the years 1912 to 1918 inclusive were published in Bulletin 163, in July, 1919.

On January 1, 1920 this project was transferred to the Soils department of the home Station.

Fertilizers for Fruit Trees. Experiments with fertilizers on bearing fruit trees are being conducted in three different locations, one in an apple orchard in the Table Rock district, one in a pear orchard near Medford, and one in a peach orchard near Ashland. This work has been in progress since 1915, and some valuable results have already been obtained.

No benefit has been derived from applications of potash, and very little, if any, from phosphorus. Applications of nitrogen in the form of nitrate of soda, nitrate of lime, and sulfate of ammonia, have in all cases increased the yield, size of fruit, and vigor of trees. This effect has been greatest on apples on the pumice soils, and on peaches on granite soil, where the increased yields and vigor of trees have been notable. On

pears the greatest effect is in increasing the size of the fruit of Winter Nelis. The fruit of this variety is usually small or medium in size except on the most favorable soils. Any fertilizer that will increase the size of the fruit will be of great value, as the largest fruit of this variety is the most profitable.

During the season 1919, the results on all of these fruits were not as well marked as during the previous years. First there was no crop on the Newtown apples in the orchard in which this experiment is being conducted, and second, there appears to be considerable seepage of irrigation water from the treated to the untreated plot in the Winter Nelis pears. A second experiment was started on peaches to include more typical soil than that on the first experimental plot. The results should be of real value during 1920 as the apple and peach crops in these orchards this year are heavy.

The earlier results of these experiments were published in Bulletin 166.

Blight Resistance in Pears. Investigations on blight resistance in pears have been in progress since the summer of 1915. The object of this work is to determine the relative resistance or susceptibility to Pear Blight of all the known species of Pyrus and also all the available varieties of cultivated pears. There has been gathered together at the station the most complete collection of pears in the world. These have been obtained from various sources including nurserymen, private collections, arboretums, missionaries, botanical gardens, experiment stations, the United States Department of Agriculture, and two very valuable collections made in the Orient by Superintendent Reimer of the branch station. Up to the present time most of the work of determining blight resistance or susceptibility has been confined to the wild types of distinct species of Pyrus. By first determining which species are resistant and which are susceptible the matter of finding resistant varieties becomes a much simpler one than would be possible without this knowledge. During the past five years repeated inoculations have shown that most of the species of Pyrus are very susceptible to Pear Blight, that three species show a fair degree of resistance, and that one species is almost totally immune, most of its forms being immune. Many cultivated varieties of pears have also been tested for blight resistance. Most of these have a very high degree of resistance. One variety obtained by Mr. Reimer on his first trip to China in 1917 has proved immune.

The results of this work will be prepared for publication at the close of the 1920 season.

Test Orchard of Pear Stocks. An experiment to determine the most satisfactory stock for American varieties of pear trees is being conducted. The seeds of the principal pear stocks of France, Japan, and China were first planted in nursery rows, and the seedlings were grafted to our leading Oregon varieties in the spring of 1919. During the spring of 1920, two small permanent orchards of these were planted so that a careful comparative study of the graft union, growth, and bearing qualities, and disease resistance can be made. Several years will be required to obtain results of value, and many years to complete the experiment.

Testing New Varieties of Pears. The station has a collection of nearly five hundred varieties of pears which are being tested from var-

ious standpoints, such as vigor of trees, character of fruit, productiveness, resistance or susceptibility to disease. Since most of these are European and Oriental varieties, entirely new to America, the information obtained from this test should be of real value to the Pacific Coast pear industry.

Pear Breeding. Important pear-breeding work was begun in the spring of 1920. The object is the production of new varieties of pears of good size, high quality, good marketing characteristics, immune or highly resistant to pear blight. The best American varieties are being crossed with Chinese varieties, which are immune to pear blight. The aim is to combine the best characteristics of these two distinct species in one variety. The work was done on a very small scale this season owing to the small number of blossoms on the young Chinese pear trees. Next year there should be an abundance of blossoms.

This will undoubtedly develop into the leading project of the station.

Disinfectants for Blight Control Work. During 1918 it was found that the old standard disinfectant, bichloride of mercury, commonly used as a disinfectant on the wounds of pear and apple trees from which pear blight had been cut, was worthless for this purpose. It is now very evident that this ineffective disinfectant has probably cost the American pear and apple industry many millions of dollars in losses. Many other of the well-known disinfectants also were found to be useless for this purpose. One disinfectant, cyanide of mercury, was entirely effective. This had never been used before in connection with blight control work.

This work was continued during the summer of 1919 with results similar to those obtained in 1918. The tests are being repeated again, with various modifications.

The results of the three years work will probably be published at the close of 1920.

EASTERN OREGON BRANCH STATION, UNION

The Eastern Oregon branch station at Union has land and equipment for experimental work with both livestock and crops. During the early days of the station, work with crops was given major attention. Later, attention was directed also to investigations in horticultural subjects and livestock problems. For several years past, major attention has been given to investigational work with livestock, the branch station and the home Station at Corvallis cooperating as centers for all livestock investigational work of the Experiment Station. The following pages give briefly the major investigations and results at the branch station during the biennium ending June 30, 1920.

Investigations With Livestock

Fattening Steers. Feeding tests in fattening steers during the winter of 1919-20 concluded six years work on this project. The tests have included trials of alfalfa alone, alfalfa and a grain ration, chopped alfalfa, and alfalfa hay and silage, as feed for fattening steers. The results, now ready for publication as Station Bulletin 174, may be summarized as follows:

Alfalfa Hay alone produced a daily gain of .88 pound when fed to two-year-old steers. The steers were given a daily ration of 37.7 pounds, of which they refused 4.9 pounds.

Chopping Alfalfa Hay for fattening steers increased its feeding value 28 percent when fed alone; 14 percent when fed with grain; and 7 percent when fed with silage. The present cost of chopping is around $3.00 per ton, hence when hay is fed in combination with either grain or silage, the improvement gained from chopping seldom justifies the expense.

Alfalfa Hay and Grain produced 30 percent more daily gain than hay alone. One pound of rolled barley replaced three pounds of alfalfa hay. It made but little difference whether a small ration of grain was fed throughout the entire feeding period or a heavy feed of grain during the latter part of the period.

Alfalfa Hay and Silage produced twice as much gain as hay alone and at half the cost.

Meadow Pasture produced a daily gain of 1 pound during the first month, 2.39 pounds the second month, 2.31 pounds the third month, and .7 pound the fourth month. Steers finished on pasture topped the market.

Growing Cattle. A series of three tests involving 216 cattle carried for two years will be concluded in November, 1920. These tests show that calves and yearlings can be economically wintered on straw supplemented with a little cottonseed or oil meal. The use of grain in any form made the cost excessive or lowered the gains made the following summer on grass. Of those considered, the more satisfactory results were secured from alfalfa hay alone and from alfalfa and silage. Silage with alfalfa or cottonseed meal gave good results but was less satisfactory when fed alone or with straw.

Fattening Lambs. A series of three years tests in fattening lambs has shown that lambs may be successfully fattened in the open without shelter but that a good shed will increase the gains sufficiently to pay interest on the investment if the shed is economically constructed. This investigation has given also a good deal of information on different feeds and combinations of feeds for fattening lambs. The results have been published as Station Bulletin 175.

Swine. A test was made in fattening eighty head of hogs for show purposes. During the first forty-five days, they were fed on bald barley, tankage, and alfalfa pasture and then for sixty days on common barley, tankage, and molasses in a dry lot. The cost of pork produced was 16 cents per pound for the first forty-five days and for the last sixty-five days 20 cents per pound.

Comparative study is being made of vegetable proteins and digester tankage in rations for growing pigs by use of the following rations: (1) rolled barley and tankage; (2) rolled barley and ground flaxseed; (3) rolled barley and cocoanut meal; (4) rolled barley and soy bean meal; (5) rolled barley and peas; (6) rolled barley and cut alfalfa hay. Ground flaxseed and cocoanut meal gave the poorest returns. Tankage, soy beans, peas, and cut alfalfa have made creditable showings.

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Forage Crops

Alfalfa. Grimm alfalfa has proved to be more vigorous and has given a greater yield than common alfalfa. This variety was first introduced into this part of the State by the Union branch station.

Clover. Tests are under way to determine the relative production of red and alsike clover and of yellow and white sweet clover for hay. The popularity of sweet clover is increasing and it is desirable to test this crop in comparison with other forage crops for both hay and pasturage purposes.

Corn. Corn is being tested as a silage crop. Due to frost conditions, however, the station is not suited to the growing of corn, and many varieties tested over a number of years have not given successful results. One variety produced locally is now showing some promise.

Peas. A test is under way to determine the yield of seed and of forage for the Canadian field pea and to study field peas in combination with bald barley and with oats for silage purposes. Excellent results have been secured from the silage tests and the field pea gives promise of becoming an important forage crop in Northeastern Oregon.

Sunflowers. A test of sunflowers to secure data on their suitability, date of planting, and rate of seeding was started in 1919. Inferior seed resulted in a very poor showing for this crop. The test is being repeated in 1920 with promise of excellent results. It is planned to use the crop for silage with which to conduct a feeding test of sunflower silage in comparison with other silage crops.

Cereals. The investigations of previous years in selection and breeding of barley, rye, and wheat have been continued on a minor scale; varietal trials of these crops have also been continued. A crop-rotation experiment and a fertilizer experiment were started in 1920.

The Fortyfold wheat distributed among the farmers from seed produced by pure-line selection at the station sold for 20 cents per bushel more than the normal price of wheat in 1919. It has proved an excellent yielding wheat as well as one of first-class milling qualities. Similar pure-line selection work is now being done with Red Chaff Club, another important wheat of Eastern Oregon.

The station has been working for a number of years on the production of a beardless rye, which is much in demand, especially by dry-land farmers. A number of plants are now available which appear to be free from beards. Much further work is necessary before these have been thoroughly tested out and enough seed produced for distribution among farmers.

The hybrid bald barleys produced by the station are now extensively grown throughout this section of the State. The demand for seed of these varieties has exceeded the supply produced by the station.

Variety tests are being conducted with barley, oats, and wheat, under both plot and field conditions.

For the past three years, the station has conducted tests in cooperation with the United States Department of Agriculture and the home Station at Corvallis to determine the smut resistance of many varieties of wheat.